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COMPUTER MODEL FOR REFINERY OPERATIONS
WITH EMPHASIS ON JET FUEL PRODUCTION
VOLUME I PROGRAM DESCRIPTION

NASA CR-135334

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| 16. Abstract The Fortran computing program will predict the flow streams and material, energy, and economic balances of a typical petroleum refinery, with particular emphasis on production of aviation turbine fuel of varying end point and hydrogen content specifications. The program has provision for shale oil and coal oil in addition to petroleum crudes. A case study feature permits dependent cases to be run for parametric or optimization studies by input of only the variables which are changed from the base case. The report has sufficient detail for the information of most readers. However, two subsequent volumes contain the mathematics and data base details and the program listing. | | | | | |
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COMPUTER MODEL FOR REFINERY OPERATIONS WITH EMPHASIS
ON JET FUEL PRODUCTION. VOLUME I PROGRAM DESCRIPTION

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SUMMARY

This report contains a description of the Gordian Refinery Simulation Model. This is a Fortran computing program for predicting the flow streams and material, energy, and economic balances of a typical petroleum refinery, with particular emphasis on production of aviation turbine fuel of varying end point and hydrogen content specifications. The program has provision for shale and coal oil in addition to petroleum crudes; 26 crude assays are supplied, and the user may add up to 9 more or update the existing assays. The program contains relationships for predicting and blending the jet fuel freezing point and smoke point as well as internal stream and product hydrogen, nitrogen, and sulfur contents and other properties. A case study feature permits dependent cases to be run for parametric or optimization studies by input of only those variables which are changed from the base case.

This report is the first of three volumes. It is independent and has sufficient detail for the needs of most readers in interpreting the program features and output data. Two subsequent volumes contain the mathematics and data base details and the program listing.

COMPUTER MODEL FOR REFINERY OPERATIONS WITH EMPHASIS
ON JET FUEL PRODUCTION: VOLUME I. PROGRAM DESCRIPTION

1.0 INTRODUCTION

Major price increases and the impending shortage of petroleum reserves with respect to increasing product demand has brought about a serious examination of possible changes in jet fuel composition. Specification aviation turbine fuel (ASTM D-1655) is produced from mid-distillate petroleum fractions, which compete with ever growing demands for diesel, fuel oil and petrochemical feedstocks. Increased distillate production from present crudes is feasible, but conversion of gas oils and residuals increases the aromatic content of the mid-distillate pool. Moreover, promising alternate crude sources, such as shale oil, tar sands, and coal liquids yield distillates also with increased aromatic, nitrogen and sulfur contents. Special processing would be required to produce present specification aviation turbine fuel from these sources.

This view of the future has stimulated a reexamination of the optimum combination of jet fuel specifications, with respect to the refinery processing, the supply distribution system, the aircraft fuel system, and the fuel combustion qualities. The goals of current studies are assessing the suitability of jet fuels produced from cracked petroleum and alternate crude sources and developing a data base which will allow optimization of future fuel characteristics. Future aviation turbine fuel specifications must represent a trade-off between energy and cost efficiency of manufacture and aircraft and engine design and performance.

This report deals with the refinery portion of the overall program. In order to have a systematic way of determining the energy efficiency of the production of various product slates involving different crude

sources and different processing schemes, the Lewis Research Center of NASA has supported the development of this computer model for petroleum refinery operation. The primary objectives of this model are:

1. the flexibility to configure a refinery involving any or all of the process units commonly employed in the production of gasoline, jet fuels, and mid-distillates;
2. the ability to produce jet fuel blends of varying end-point specification and varying specified hydrogen content as part of the total slate of products;
3. the ability to handle synthetic crudes (shale and coal derived) with varying severities of hydroprocessing;
4. the determination of overall refinery energy efficiency;
5. the determination of sulfur, nitrogen, and hydrogen material balances for each process unit and for the overall refinery; and
6. the capability of carrying out economic calculations.

The Gordian Refinery Simulation Model, presented herein, has all the above capabilities. This report, Volume I of three volumes, contains the detailed information necessary to run the program, and a brief discussion of the technical basis of the model and its limitations in the present state. Volume II (NASA CR-135334) contains details of the mathematical relations and data bases used in the program, and Volume III (NASA CR-135335) contains programming documentation. The complete documentation and program tape are available through the Computing Software and Management Information Office (COSMIC) under the number LEW-13047.

2.0 PROGRAM DESCRIPTION AND LOGIC

2.1 General Description and Applications

The Gordian Refinery Simulation Model is a Fortran computer program which is capable of predicting the production volumes of petroleum refinery products, with particular emphasis on aircraft turbine fuel blends and their key properties. The program also provides the calculation of capital and operating costs for the refinery and its margin of profitability. This model is noteworthy in that it includes provision for the processing of synthetic crude oils from oil shales and coal liquefaction processes. The program provides highly detailed blending computations for alternative jet fuel blends of varying end-point specification. Volumetric and weight balances are output along with complete sulfur, nitrogen and hydrogen balances. Energy usage is reported in terms of net fuel power and steam consumption along with the hydrogen usage. Results are reported in SI metric and English units.

In order to use the program, it is necessary to specify the type and volume of each crude oil which makes up the feed to the refinery as well as the capacities of the specific refinery processing units which comprise the refinery configuration. The complete slate of refinery products is then calculated by the program, with particular emphasis on accurately predicting the volumes and properties of the jet fuel, distillate and residual fuel oil blends produced. The economic calculations require the input of crude oil prices, refinery product realizations, electricity cost and investment carrying charge.

While the model simulates the operation of a refinery, it does not optimize it with respect to maximum dollar profit in the way that a linear programming model does. The non-linear relationships which have been programmed (e.g. for turbine fuel smoke point and freezing point prediction) allow for greater accuracy than may be obtained in calculating the product blends normally obtainable with the conventional linear programming approach. An additional advantage is that less training is required and less data input and program usage complexities are encountered in using a Fortran program as opposed to a complex linear programming system.

Optimization and parametric type studies in general, however, may be made by using the case study feature which has been incorporated into the model. This feature is used by establishing a base case and then by specifying only the changes to the base case which are applicable to the case study sequence, thus minimizing input requirements and permitting large case study sequences to be run without undue user or computer time.

Two major data base subroutines are contained within the program, a Crude Assay subroutine and a Refinery Process Yield subroutine. The Crude Assay subroutine is comprised of the yields and properties of distillation products from a wide range of crude oils. The Refinery Process Yield subroutine contains typical process unit yields, energy requirements and stream quality factors for a variety of refinery processing units. In addition, an economic data base is contained in the model which provides the fixed and variable components of operating costs and investment costs for individual refinery process units.

Five potential categories of fuels production are considered by the Refinery Model:

1. Kerosene/Aviation turbine fuel
2. Diesel fuel
3. Direct gas oil sale
4. Distillate Fuel
5. Residual Fuel
6. Gasoline

The volumes of kerosene, diesel fuel and gas oil to be produced (if any) are specified in the input. Any excess kerosene or diesel is routed to turbine or distillate fuel while the remaining gas oil is either processed or blended directly to residual fuel.

An aviation turbine fuel blending subroutine calculates product blends at end-points of 525°F and 650°F, and any specified intermediate end-point. In addition, the user has the option of specifying the required hydrogen content for a given end-point turbine fuel, and the model will calculate the maximum quantity of fuel that can be produced to meet specification. Other properties of the kerosene/turbine fuel pool that are calculated are gravity (°API), sulfur content, nitrogen content, viscosity, freeze point, smoke point, paraffins, naphthenes, aromatics and heat of combustion.

The distillate and residual fuel oils usually comprise the bulk of the fuel oil production. The model calculates the following for both the distillate fuel and residual fuel oil pools:

1. Total pool volumes
2. Weight percent sulfur
3. Weight percent nitrogen
4. Weight percent hydrogen

5. API gravity

6. Viscosity

If desired, sulfur contents may be specified for distillate and residual fuel oil blends. The model will then calculate the maximum fuel oil volumes available at the specified sulfur contents, along with the other fuel oil properties. In order to make particular sulfur specifications, it is usually necessary to reject blending components from the total fuel oil pools. The model calculates the volume, sulfur content, and the other fuel oil properties of the "rejected" portions of the distillate and residual fuel oil pools.

If desired, the production volume and sulfur content of one or two distillate fuel oil blends may be specified. The program will calculate the composition and properties of these blends and will blend the remaining excess distillate components into the residual fuel oil pool. One or two residual fuel oil blends of fixed volume and sulfur content may also be specified. The composition and properties of these residual fuel oil blends (which now contain excess middle distillate components) will be calculated along with the volume and properties of the remaining residual fuel oil pool.

Use of the above blend specification options affords considerable flexibility in assessing the production capabilities in a given refining situation for fuels ranging from aircraft turbine level to residual fuel oil.

2.2 Technical Basis for Model

A brief summary of the technical background of the computer model is presented in this section. This information is given in more detail

in Volume II (NASA CR-135334).

The model has storage capability for up to 35 crude assays. At present, the program contains within a subroutine 26 assays, including three shale oils and one coal syncrude. The petroleum crude assays were obtained from Gordian Associates, Inc. in-house data and from assays published in the Oil and Gas Journal. The shale and coal syncrude assay data were obtained from references 1 and 2. In those cases where a crude oil property needed for the program was not available from the assay data, either a correlation was used to derive the property or an estimate was used. Such cases are noted in Volume II.

Process unit yield data for the petroleum-derived fractions were obtained from Gordian in-house data and from ref. 3, and for the syncrude fractions from references 1 and 2. The process unit yield data base includes the energy requirements for each unit in the form of steam, refinery gas, and electrical power.

Several physical and chemical property blending correlations that are used in this model are summarized as follows:

1. Hydrogen content, if not specified as input or through the assay, is calculated from API gravity and mean average boiling point by the method described in ref. 4 for petroleum fractions. The same method, but with adjustments to the predicted carbon-hydrogen ratio, was used for the shale oil and coal oil cuts.

2. Heats of combustion were calculated from API gravity, Watson characterization factor, and sulfur content by a correlating relation also obtained from ref. 4. Heat of combustion is blended by weight.

3. Smoke points were calculated from Watson characterization factor by equations derived from data in ref. 5. Smoke point is blended volumetrically by a reciprocal blending relation.

4. Freezing point data, if not available through assay data, were estimated from a correlation presented in ref. 5. Freezing points of product streams from the process units were based upon changes in freezing point from the feed streams in order to tie the product freezing points as much as possible to the original crude oil assays. Freezing point blending of the jet fuel and mid-distillate blends was based on the blending index method of ref. 6.

5. Sulfur and nitrogen content, viscosity, and PNA (paraffins, naphthenes and aromatics) are based on crude assay values and on inspection tests accompanying process unit yield data. Viscosities are blended as shown in Exhibit 6 of this volume; the other properties here are blended by volume.

6. The economic calculation for the specific refinery configuration under study includes investment costs for the individual process units, off-site investment costs, fixed and variable operating costs. Crude or other feedstream costs, utility costs, product prices and rate of return on investment must be input for the particular case.

Some cautions regarding the use of the Gordian Refinery Simulation Model in its present form must be noted. Process unit data and correlations involving petroleum-derived fuels have a broad base of years of experience in the petroleum industry, and the calculations involving the use of petroleum crudes can be expected to have good reliability. Processing data and correlations involving shale or coal-derived fuels, however, are extremely limited at the present time, and the results calculated using these syncrudes would be expected to be much less reliable.

Nevertheless, it was desired to have a refinery simulation model which would be capable of handling these syncrudes, with the intent of continually upgrading the data and correlation bases as such information becomes available.

2.3 Review of Model Output

In order to provide an illustration of the capabilities of the model this section provides a review of the complete computer printout for a sample case. A copy of an actual computer output is shown in Exhibit 1. The computer print-out reports appear in the order in which the calculation proceeds within the model. While all of the report writing capabilities of the program are shown, there are options to selectively suppress various reports in a manner to be specified by the user.

The first set of reports give individual process unit material balances with respect to weight flow rate, sulfur, nitrogen, and hydrogen. Each material balance process unit report is followed by an energy utilization report showing the consumption of fuel, steam, electricity and hydrogen and their percentage of the total fuel oil equivalent (FOE) input to the refinery. Please note that while the hydrogen unit balance appears in error, this results from the fact that water feed and carbon dioxide product has been excluded from the weight balance as normal refinery practice.

The second set of reports refer to the jet fuel blends which may be produced by the combination of the specified refinery crude oil feedstocks and refinery process unit configuration. These reports have been generated to provide the full extent of jet fuel blending information which is available from the model. These blend reports are:

exact matches (except where sulfur and nitrogen is truly lost through the combustion of catalytic coke) since the process unit data base values are expressed in the program as a percentage distribution of sulfur and nitrogen between process unit products. Hydrogen distribution on the other hand, is not handled in this manner, but is calculated from an API Technical Data Book correlation (ref. 4) which relates hydrogen content to specific gravity and the mean average boiling point of the stream, with adjustment factors applied for coal and shale oil fractions. The overall hydrogen of 100.9 weight percent appears good, but is deceptive. While the results for units which process petroleum fraction is generally good, rather significant discrepancies can be observed for the shale and coal oil processing units. The reason here is a combination of relatively weak process unit data available at the present time to relate yields to hydrogen consumption and downstream product qualities, and probable deficiencies in the correlation used to predict hydrogen content for the shale and coal oil species.

A summary of process unit operations is next shown which compares the input process unit capacity with the actual feedrate. Process unit severities are also given. Separate reports are printed which summarize the overall refinery energy efficiency and usage and the properties of the blended gasoline pool.

The final section of the computer printout report gives an overall economic summary of refinery operations. The profit margin calculations shown are illustrative only since actual crude oil prices, product realizations, and investment carrying charges depend on the specific refining situation. However, the process unit investment costs and operating costs are contained in the program as data base items. These

- (a) Properties of the total 525°F endpoint pool
- (b) Properties and quantity of 525°F endpoint pool at the specified hydrogen content. (12.8 weight percent in this run).
- (c) Properties of the total 650°F endpoint pool
- (d) Properties and quantity of 650°F endpoint pool at the specified hydrogen content.
- (e) Properties of the total pool at the specified endpoint (600°F in this run)
- (f) Properties and quantity of the specified endpoint blend at the specified hydrogen content.

Separate auxiliary reports are shown which give the properties of the total middle distillate pool (which include cracked olefinic stocks which are normally diverted from jet fuel), and the residual fuel oil pool.

A summary material balance report shows the disposition of mass, sulfur, nitrogen and hydrogen between feed streams and final products*. Overall recoveries are given at the bottom of this report. Note that the volumetric recovery is reasonable for a refinery of the specified configuration. The weight recovery is less than 100.0 of weight percent, reflecting the fact that weight balances for the individual process units have not been forced through the proration of discrepancies. The lower sulfur and nitrogen recoveries are due almost entirely to crude unit imbalances which reflect inconsistencies in the basic crude assay data. In general, basic data of this type has not been adjusted through internal program computations because to do so would cause the program user to lose sight of those data base areas which could be improved. Sulfur and nitrogen balances for the downstream units, however, provide

* The middle distillate blend reported here is the balance remaining after the specified jet fuel blend has been made.

were obtained by a general review of today's petroleum refining costs and are expressed in current 1977 dollars, with no built-in inflation. Crude prices, product realizations, electricity cost and investment carrying charge must be input since they are specific to a given situation.

Additional information provided in the front of the report printout show the input data cards as punched. The items appearing under the headers &CDATA, &UDATA and &UDATA1 are for illustrative purposes only -- data input under these cards allows for user directed changes to any of the data base values contained in the crude oil assay data base subroutine (CBASE) and the process unit data base subroutine (UBASE). This capability can prove valuable for simulating specific refining situations.

2.4 Program Logic

An overall block diagram describing the logic of the Gordian Refinery Simulation Model is shown in Exhibit 2. A brief functional description comprising the Gordian Refinery Simulation Model follows:

MAIN PROGRAM - The main program blends crude oil properties, calculates the refinery volumetric balance, calculates the overall refinery material balance, issues summary reports and sets up the subroutine calling sequence.

BLOCK DATA - Contains initialization data used throughout the program and refinery process unit cost data used by the economic subroutine.

CONAPI - Converts from API to specific gravity and back as required.

ISTN - Sets stream number identities used by the main program and the report subroutines.

CBASE - Contains the crude assay data base.

UBASE - Contains the refinery process unit yield and stream quality data base.

MATCLC - Performs all material balance calculations required for the weight, sulfur, nitrogen and hydrogen balance around each of the refinery process units.

INITB - Initializes default input value for each base case run.

UNTREP - The report writer subroutine for the individual process unit material balances.

UNTENR - The report writer subroutine for energy usage consumed by each refinery process unit.

ECON - Does the refinery economics calculation and outputs summary reports.

HYDCAL - Calculates the hydrogen content of every refinery process stream as a function of specific gravity and mean average boiling point -- unless a value has been pre-specified in UBASE or input.

INITV - Initializes intermediate program variables.

BLDARY - Sets up blending stream proprieties for each stream used in jet fuel, middle distillate and residual fuel blends.

BLENDF - Contains the calculation sequence for each of the jet fuel blend combinations and the middle distillate and residual fuel oil blends.

SSORT1 - Sorts jet fuel blending components according to their hydrogen content ranking.

BLDREP - The report writer subroutine for turbine fuel, middle distillate and residual fuel oil blends.

BPROP - Calculates blend properties and contains freezing point and smoke point blending correlations.

SSORT - Sorts blend components by sulfur content ranking - used for calculating middle distillate and residual fuel oil blend combinations.

BMAX - This subroutine calculates the maximum quantity of jet fuel blend production of a specified hydrogen content, or maximum middle distillate or residual fuel of a specified sulfur content.

A more detailed and comprehensive description of the programming aspects of the Gordian Refinery Simulation Model is given in Volume II (NASA CR-135334) and Volume III (NASA CR-135335).

2.5 Summary of Model Options and Flexibility

Any combination of crude oils represented in the Crude Assay subroutine may be selected by specifying their code number and the

charge volume of each crude; including shale oil and coal liquefaction products. If the feed to the refinery contains crude oils which are not represented in the Crude Assay subroutine, then the yields and properties of these crudes may be input directly into the model along with their volumes. If individual refinery charge streams, such as purchased gas oil, distillate cutter stocks, and naphthas are a part of the refinery charge, these may also be specified by giving their feed volumes and stream properties.

The volumes of up to four separate "imported" fuel oil blending components (kerosene, diesel, gas oil, and residuum) may be specified along with their properties in order to simulate the refinery operation. These components enter directly into fuel oil blending without being mixed with other streams.

The block flow diagram of the refinery processing units is shown as Exhibit 3. The following process units may be specified when defining the refinery process unit configuration:

- (1) Atmospheric crude distillation (petroleum-based, shale oil, coal oil)
- (2) Vacuum crude oil distillation (petroleum-based, shale oil, coal oil)
- (3) Catalytic gas oil cracking
- (4) Thermal gas oil cracking
- (5) Middle distillate desulfurizer
- (6) Kerosene Hydrotreater (separate units for petroleum stocks, coal based and shale oil stocks)
- (7) Fluid coking
- (8) Vacuum bottoms visbreaking
- (9) Middle distillate and gas oil hydrocracking (separate gas oil hydrocracking units for petroleum stocks, coal-based and shale oil stocks)

(10) Catalytic naphtha reforming

(11) Alkylation

(12) Polymerization

(13) Butane isomerization

(14) Hydrogen production

Variables which serve to describe internal refinery operations are also a part of the input. The catalytic cracker severity (percentage conversion), the naphtha reformer severity (octane), the type of petroleum-based gas oil hydrocracking operation (gasoline versus distillate production, and the severity of shale oil and coal oil hydrocracking and hydrotreating operation must be specified either directly (or will be by default) if these units are included in the overall refinery configuration. In a complex refinery where internal streams such as diesel oil and coker and vacuum gas oil have alternative dispositions, the fraction of each such stream going to alternative refinery process units may be specified. If fractional dispositions are not specified, the default is to prorate internal refinery stream to alternative down stream units by the ratio of their stated capacities.

In some instances it may be desirable to replace the typical refinery process yields contained in the Refinery Process Yield subroutine with yield and quality numbers which more exactly represent a particular refinery. This could occur if a particular refinery was atypical in some respects or if a rather close match of unusual refinery operations was desired. For this reason, the option exists to override any of the data base values contained in the Refinery Process Yield subroutine by specifying them in the input.

With regard to the refinery process unit capacities, it would be unusual for a specified unit throughput to exactly match the volume of an intermediate refinery stream. If the unit is undersized, the excess feed stock is blended off or is downgraded. If the unit is oversized, the slack processing capacity is reported. Both situations are handled automatically by the program logic.

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3.0 REQUIRED MODEL INPUTS

3.1 General Rules for Fortran Namelist Input

Punched card input is read directly by the Fuel Blending Model using the Fortran Namelist feature. This feature allows for a "free format" type of input whereby the data may be input in any sequence. However, certain input rules must be observed and they are listed below.

- The first card heading up the input for a new run or case must contain an ampersand (&) in column 2 followed by the name of the data list (see Section 3.2 for the instructions for specifying data lists for the Gordian Simulation Model).
- A variable name must be completed on a card, but may begin in any location from column 2 onwards. Card column 1 is never to be used for any purpose.
- More than one variable name and more than one data entry may appear on a card, the only requirement being that they be separated by commas.

For example:

FCC=30000.0, GASOIL=2000.0, GOHYC=5000.0, MODE=2, is a legitimate card entry with FCC starting in card column 2 onwards. As shown above, the = sign must immediately follow the symbolic variable name and there may be no blank space appearing within the symbolic variable name. However, the data values following the equal sign may be spaced on the card, as long as the last item entered on a data card is always a comma.

For example:

FCC= 30000.0, GASOIL= 2000.0,

GOHYC= 5000.0, MODE= 2,

are legitimate entries for two successive input cards.

- Elements of input arrays, such as the array of crude oil volume feed rate, must be input with the array element number indicated in parentheses. For example:

CV(8)= 50000.0, CV(10)= 40000.0,

would indicate fifty and forty thousand barrels per day of crude oils #8 and #10, respectively. No intervening blanks should appear in designating an input variable of this type. For example, do not input

CV (8) = 50000.0,

- Data types must be respected. For example:

MODE=2, ICASE=1, TITLE= 'TEST RUN', FCC= 30000.0, CV(1)=50000.0, is correct in every respect. The four variable types used in this program are:

- . Literal variables, which appear between quotation marks and which may consist of any combination of alphabetic or numeric information. The only variable of this type appearing in this program is TITLE, which is used to provide a run or case title.
- . Integer variables (such as ICASE and MODE) which are always followed by whole numbers, without a decimal point.

- . Real variables (such as FCC=30000.0, VGOFCC=0.45,) which are followed by numbers containing decimal points.
- . Real variables, which are also array elements (such as CV(1)=50000.0, CV(10)=20000.0, CA(2,22)=0.03
- The last card denoting the end of an input data list must contain &END, beginning in column 2 with no intervening blanks.

3.2 Detailed Description of Specific Inputs

The following section describes the program input using the FORTRAN namelist feature, item by item. If a particular input, or a group of inputs, is not relevant to the problem at hand, they may be omitted. A list of the program default values for each specific input is given in Section 3.3. With a few exceptions, the program default values are usually zero.

In this section the data type and the appropriate units are given for each input variable. The following abbreviations are used for units:

| | |
|--------|---|
| BPD | Barrels per day. These are on a calendar day basis (BPCD). The program makes stream day adjustments based on the value of the input stream factor STRF. |
| MMSCFD | Millions of standard cubic feet per day. |

The input data stream sequence is organized as follows:

```
&CDATA ... crude oil assay data base changes (optional)
&END
&UDATA ... process unit data base changes (optional)
&END
```

&UDATA1 ... process unit data base changes (optional)
&END
&PDATA ... input defining the refinery feed, product and process
&END unit size characteristics (required)

While crude oil and process unit data base changes are optional, the header cards (which contain an ampersand in column 2) are required at the beginning of the input data stream run sequence, even if no change cards are input.

The input data items appearing between the headers &PDATA and &END are described in sections 3.2.1, 3.2.2, and 3.2.7 to 3.2.9. Default values are automatically established within the program, as discussed in section 3.3; hence input data are required only where different from the default values. The optional crude oil assay data items appearing between the headers &CDATA and &END are described in section 3.2.3. Optional process data change items appearing between &UDATA and &END are those described in sections 3.2.4 and in section 3.2.5 except for viscosity and research octane variables. Optional process data change items appearing between &UDATA1 and &END are the viscosity and octane variables and the items described in section 3.2.6.

3.2.1 Title and Case Study Feature

| <u>Name</u> | <u>Type</u> | <u>Units</u> | <u>Description</u> |
|-------------|-------------|--------------|--|
| TITLE | Literal | - | The run or case title which will appear at the top of each output page. Up to 70 alpha-numeric characters may be used. |
| ICASE | Integer | - | <p>The case study indicator. If not entered it is assumed that the run is a "stand alone run" with no fixed relation to preceding or succeeding runs. Input ICASE=1 for the starting base case of a case study sequence.</p> <p>Input ICASE=2 for a subject case to be dependent on the starting case.</p> <p>Input ICASE=3 for the final case of a case study sequence.</p> <p>A case study sequence may be followed by stand alone runs or a new case study sequence can be initiated, if desired.</p> <p>The program logic is such that all subject case changes are made to the starting base case of a case study sequence. Therefore, subject case changes are not additive in nature.</p> |

3.2.2 Process Unit Capacities, Modes of Operation and Internal Stream Disposition

| <u>Name</u> | <u>Type</u> | <u>Units</u> | <u>Description</u> |
|-------------|---------------|-------------------|---|
| CV(N) | Real Array | BPD | The crude unit charge rate of crude N, where the code integer N applies to a specific crude. A list of those crudes currently represented in the model is given in Exhibit 4, attached. |
| VACD | Real | BPD | The vacuum distillation capacity. For petroleum-based, expressed as reduced crude feedrate. |
| VACS | Real | BPD | The vacuum distillation capacity for shale oil based crude. |
| VACC | Real | BPD | The vacuum distillation capacity for coal oil based synthetic crude. |
| FCC* | Real | BPD | The refinery catalytic cracking capacity, expressed as total gas oil feedrate (fresh feed). |
| CONV | Real | Volume Percent | The conversion (percentage gas oil disappearance) of the fluid catalytic cracking unit. |

* Presently available data is limited to petroleum based fractions. The shale and coal oil hydroprocessing units should be specified for processing those species.

| <u>Name</u> | <u>Type</u> | <u>Units</u> | <u>Description</u> |
|-------------|-------------|--------------|--|
| ALKY | Real | BPD | The refinery alkylation unit capacity expressed as total alkylate product. |
| POLY | Real | BPD | The refinery polymerization unit capacity expressed as polymer product rate. |
| MDES* | Real | BPD | The refinery middle distillate desulfurizer feed capacity expressed as total feed rate. |
| GODES* | Real | BPD | The refinery gas oil desulfurizer feed capacity expressed as total feed rate. |
| SOKHT | Real | BPD | The refinery shale oil kerosene hydrotreater capacity expressed as kerosene feed rate. |
| SVSKHT | Integer | - | The designated mode of operation of the shale oil kerosene hydrotreater. Enter 1 for mild, 2 for intermediate, and 3 for severe operation. |
| COKHT | Real | BPD | The refinery coal oil kerosene hydrotreater capacity expressed as kerosene feed rate. |
| SVCKHT | Integer | - | The designated mode of operation of the coal oil kerosene hydrotreater. Enter 1 for mild, 2 for intermediate, and 3 for severe operation. |
| SGOHC | Real | BPD | The refinery shale oil gas oil hydrocracker capacity expressed as total feed rate. |
| SVSGHT | Integer | - | The designated mode of operation of the shale oil gas oil hydrocracker. Enter 1 for mild, 2 for intermediate, and 3 for severe operation. |
| CGOHC | Real | BPD | The refinery coal oil gas oil hydrocracker capacity expressed as total feed rate. |
| SVCGHT | Integer | - | The designated mode of operation of the coal oil gas oil hydrocracker. Enter 1 for mild, 2 for intermediate, and 3 for severe operation. |
| COKER | Real | BPD | The refinery coker unit capacity expressed as vacuum bottoms feed rate. |
| VB | Real | BPD | The refinery visbreaker unit capacity expressed as vacuum bottoms feed rate. |
| TCC | Real | BPD | The refinery thermal cracker unit capacity expressed as gas oil feed rate. |

* Specify these units for processing petroleum based fractions. Specify the shale and coal oil hydroprocessing units for processing those species.

| <u>Name</u> | <u>Type</u> | <u>Units</u> | <u>Description</u> |
|-------------|-------------|----------------------------|--|
| MDHYC* | Real | BPD | The refinery middle distillate hydrocracker capacity expressed as total feed rate. |
| GOHYC* | Real | BPD | The refinery petroleum gas oil hydrocracker capacity expressed as total feed rate. |
| MODE | Integer | - | The designated mode of operation of the refinery gas oil hydrocracker. Enter MODE=1 for a gasoline operation and MODE=2 for a middle distillate operation. |
| BI | Real | BPD | The refinery butane isomerization capacity expressed as the normal butane feed rate. |
| HYD | Real | MMSCFD | The refinery hydrogen unit capacity expressed as the hydrogen production rate. |
| REF | Real | BPD | The refinery catalytic naphtha reformer capacity expressed as total naphtha feed rate. |
| REFRON | Real | Research Octane No., Clear | The catalytic reformer severity expressed as the clear research octane number of the total platformate. |
| HTKERO | Real | BPD | The refinery petroleum kerosene hydrotreater capacity expressed as the kerosene feed rate. |

Internal Stream Dispositions

If alternative destinations exist for any of the internal refinery streams, the following inputs serve to define the fraction of the stream being routed to each alternative process unit (values for these variables should not be input for a given stream if the refinery configuration is such that multiple destinations do not exist). The programmed default is to prorate stream volume by the ratio of available downstream process unit capacities.

* Specify these units only for processing petroleum based fractions. Specify the shale and coal oil hydroprocessing units for processing those species.

If the total of the sum of the volume fractions going to alternative destinations for a particular stream are specified at less than 1.0, the balance of that stream is assumed to go directly to fuel oil blending.

For the low-boiling internal streams (methane, ethane, propane, butanes, and the corresponding olefins), distribution priorities are prescribed. Alkylation has the first priority for isobutane and butylene. The polymerization unit uses propylene first, and if additional capacity is left, it uses the excess butylene. For hydrogen production, propane is used first and then ethane and lighter. The overall hydrogen requirements of the refinery are filled by first the hydrogen produced by the catalytic reformer and then, if needed, by hydrogen from the hydrogen plant. The balance of the low-boiling streams not used internally goes to fuel gas and LPG.

| <u>Name</u> | <u>Type</u> | <u>Units</u> | <u>Description</u> |
|-------------|-------------|-----------------|--|
| DSLDES | Real | Volume Fraction | The volume fraction of the refinery diesel stream going to the middle distillate desulfurizer. |
| DSLMDH | Real | Volume Fraction | The volume fraction of the refinery diesel stream going to the middle distillate hydrocracker. |
| LCODES | Real | Volume Fraction | The volume fraction of light catalytic cycle oil going to the middle distillate desulfurizer. |
| LCOMDH | Real | Volume Fraction | The volume fraction of light catalytic cycle oil going to the middle distillate hydrocracker. |
| VGODES | Real | Volume Fraction | The volume fraction of the refinery gas oil stream going to gas oil desulfurization. |
| VGOHYC | Real | Volume Fraction | The fraction of the above stream going to gas oil hydrocracking. |
| VGOFCC | Real | Volume Fraction | The fraction of the above stream going to gas oil catalytic cracking. |
| VGOTCC | Real | Volume Fraction | The fraction of the above stream going to gas oil thermal cracking. |

| | | | |
|----------------------------|------|---------------------|--|
| CGODES COGOHY CGOFCC | Real | Volume Fractions | These three input variables denote the volume fraction of total coker gas oil to the respective destinations listed above. |
| VBTMVB | Real | Volume Fraction | The volume fraction of vacuum bottoms going to the visbreaker. |
| VBTMCO | Real | Volume Fraction | The volume fraction of vacuum bottoms going to the coker. |
| SLKKHT | Real | Volume Fraction | The volume fraction of light kerosene (400 to 525°F EP) going to the shale oil kerosene hydrotreater. |
| SHKKHT | Real | Volume Fraction | The volume fraction of heavy kerosene (525 to 650°F EP) going to the shale oil kerosene hydrotreater. |
| CLKKHT | Real | Volume Fraction | The volume fraction of light kerosene (400 to 525° F EP) going to the coal oil kerosene hydrotreater. |
| CHKKHT | Real | Volume Fraction | The volume fraction of heavy kerosene (525 to 650°F EP) going to the coal oil kerosene hydrotreater. |
| SGOHC | Real | Volume Fraction | The volume fraction of gas oil going to the shale oil gas oil hydrocracker. |
| CGOHC | Real | Volume Fraction | The volume fraction of gas oil going to the coal oil gas oil hydrocracker. |

3.2.3 Crude Assay Information

The following input variables relate to the crude oil assay information which may be entered directly as input. The values may apply to entirely new feeds or may be used to override crude oil assay information currently stored in the model. The crude assay data changes are entered first in the sequence between the &CDATA and &END header cards.

Crude oil assay code numbers 1 through 26 are reserved for crude oil assays presently stored within the program. Code numbers 27 through 35 may be used to describe crude oils and feeds which are not in the permanent data base. A list of data base crude oils is given in Exhibit 4.

Refinery charge streams such as gas oils may be specified by entering a fractional gas oil yield of 1.0 for the crude assay, along with the gas oil properties. The remaining crude oil assay values are not to be input in this instance since the gas oil data has fully described the refinery charge stream. This input data philosophy may be extended to any type of refinery charge stream, naphtha, kerosene, diesel, etc., which is imported to the refinery for processing within the normal plant sequence.

| <u>Name</u> | <u>Type</u> | <u>Units</u> | <u>Description</u> |
|-------------|---------------|---------------------------------|---|
| CA(N,1) | Real Array | Volume Fraction (BBL/BBL) | Crude assay yield of ethane and lighter for crude N. |
| CA(N,2) | " | " | Yield of propane. |
| CA(N,3) | " | " | Yield of isobutane. |
| CA(N,4) | " | " | Yield of normal butane. |
| CA(N,5) | " | " | Yield of pentane. |
| CA(N,6) | " | " | Yield of light straight run gasoline. (IBP-250°F) |
| CA(N,7) | " | " | Yield of heavy straight run naphtha- reformer feed. (250 to 400°F) |
| CA(N,8) | " | " | Yield of light kerosene (400 to 525°F). |
| CA(N,9) | " | " | Yield of heavy kerosene (525 to 650°F). |
| CA(N,10) | " | " | Yield of vacuum gas oil (650 to 1,050°F EP). |
| CA(N,11) | " | " | Yield of vacuum bottoms (1,050°F +). |
| CA(N,12) | " | Degrees API Gravity | Crude oil API gravity. |
| CA(N,13) | " | " | Light straight run API gravity. |
| CA(N,14) | " | " | Heavy straight run API gravity. |
| CA(N,15) | " | " | Light kerosene API gravity. |
| CA(N,16) | " | " | Heavy kerosene API gravity. |

| | | | |
|----------|---------------|--------------------------------|--|
| CA(N,17) | " | " | Vacuum gas oil API gravity. |
| CA(N,18) | " | " | Vacuum bottoms API gravity. |
| CA(N,19) | " | Weight Percent | Crude oil sulfur content. |
| CA(N,20) | " | " | Light straight run sulfur content. |
| CA(N,21) | " | " | Heavy straight run sulfur content. |
| CA(N,22) | Real Array | Weight Percent | Light kerosene sulfur content. |
| CA(N,23) | " | " | Heavy kerosene sulfur content. |
| CA(N,24) | " | " | Vacuum gas oil sulfur content. |
| CA(N,25) | " | " | Vacuum bottoms sulfur content. |
| CA(N,26) | " | " | Crude oil nitrogen content. |
| CA(N,27) | " | " | Light straight run nitrogen content. |
| CA(N,28) | " | " | Heavy straight run nitrogen content. |
| CA(N,29) | " | " | Light kerosene nitrogen content. |
| CA(N,30) | " | " | Heavy kerosene nitrogen content. |
| CA(N,31) | " | " | Vacuum gas oil nitrogen content. |
| CA(N,32) | " | " | Vacuum bottoms nitrogen content. |
| CA(N,33) | " | " | Crude oil hydrogen content. |
| CA(N,34) | " | " | Light straight run hydrogen content. |
| CA(N,35) | " | " | Heavy straight run hydrogen content. |
| CA(N,36) | " | " | Light kerosene hydrogen content. |
| CA(N,37) | " | " | Heavy kerosene hydrogen content. |
| CA(N,38) | " | " | Gas oil hydrogen content. |
| CA(N,39) | " | " | Vacuum bottoms hydrogen content. |
| CA(N,40) | " | Viscosity Blending Index | Light kerosene viscosity index at 210°F. |
| CA(N,41) | " | " | Heavy kerosene viscosity index at 210°F |
| CA(N,42) | " | " | Gas oil viscosity index at 210°F. |

| | | | |
|----------|---------------|-------------------|---|
| CA(N,43) | " | " | Vacuum bottoms viscosity index at 210°F. |
| CA(N,44) | Real Array | Weight Percent | Light kerosene paraffin content. |
| CA(N,45) | " | " | Light kerosene naphthene content. |
| CA(N,46) | " | " | Light kerosene aromatics content. |
| CA(N,47) | " | " | Heavy kerosene paraffin content. |
| CA(N,48) | " | " | Heavy kerosene naphthene content. |
| CA(N,49) | " | " | Heavy kerosene aromatics content. |
| CA(N,50) | " | °F | Light kerosene freezing point. |
| CA(N,51) | " | °F | Heavy kerosene freezing point. |
| CA(N,52) | " | mm | Light kerosene smoke point. |
| CA(N,53) | " | mm | Heavy kerosene smoke point. |
| CA(N,54) | " | BTU/# | Crude oil heat of combustion. |
| CA(N,55) | " | " | Light kerosene heat of combustion. |
| CA(N,56) | " | " | Heavy kerosene heat of combustion. |
| CA(N,57) | " | - | Species indicator 1.0 = Coal Oil 2.0 = Shale Oil 3.0 = Petroleum |

Note: N corresponds to the crude oil code number given in Exhibit 4. The boiling point distillation ranges of the liquid crude oil cuts are given in parentheses and correspond to ASTM D-86 boiling points. The Viscosity Blend Index referred to is described in Exhibit 6.

3.2.4 Process Unit Data

The following input variables affect the internally stored program values of the process unit yields and utility consumptions. It is only necessary to input these variables when it is desired to replace the data stored for any of the process units with values of the user's choice. Changes to the process unit data base are entered second in the input sequence, after the crude assay data base changes between &UDATA and &END header cards.

All of the input variables listed below are elements of real arrays. The units are fractional barrels of the particular stream yielded per barrel of the indicated feed stream. Coke, hydrogen, refinery gas, and process unit steam and fuel consumption are in barrels of fuel oil equivalent per barrel of feed.* Electricity usage is in kilowatt hours (KWH) per barrel of process unit feed. If the process unit produces steam as opposed to using it, a negative number should be entered for steam consumption.

As may be seen from analyzing the input variable names listed below, all of the product streams have been assigned characteristic code numbers. These are listed in Exhibit 5.

| <u>Crude Unit, Per Barrel of Crude Oil Feed</u> | <u>Petroleum</u> | <u>Shale Oil</u> | <u>Coal Oil</u> |
|---|---|-----------------------|-----------------|
| Steam consumption | CUPYLD(1) | CUSYLD(1) | CUCYLD(1) |
| Fuel consumption | CUPYLD(2) | CUSYLD(2) | CUCYLD(2) |
| Electricity consumption | CUPYLD(3) | CUSYLD(3) | CUCYLD(3) |
| | <u>Visbreaker per barrel of vacuum bottom</u> | <u>Coker feed</u> | |
| Steam consumption | VBYLD(1) | COYLD(1) | |
| Fuel consumption | VBYLD(2) | COYLD(2) | |
| Electricity consumption | VBYLD(3) | COYLD(3) | |
| Refinery gas yield | VBYLD(5) | COYLD(5) | |
| Propane yield | VBYLD(6) | COYLD(6) | |
| Propylene yield | VBYLD(7) | COYLD(7) | |
| Isobutane yield | VBYLD(8) | COYLD(8) | |
| Normal butane yield | VBYLD(9) | COYLD(9) | |
| Butylene yield | VBYLD(10) | COYLD(10) | |
| Light gasoline | VBYLD(31) | COYLD(31) | |
| Heavy gasoline | VBYLD(32) | COYLD(32) | |
| Total gas oil | VBYLD(35) | COYLD(35) | |
| Coke | - | COYLD(36) | |
| Pitch | VBYLD(51) | - | |

* 6,050,000 BTU per barrel fuel oil equivalent (BFOE), corresponding to the net heating value.

Catalytic Cracker Yields

| | <u>@ low conversion</u> | <u>@ high conversion</u> |
|-------------------------|--|--------------------------|
| | <u>per barrel of vacuum gas oil feed</u> | |
| Steam consumption | CGYLDL(1) | CGYLDH(1) |
| Fuel consumption | CGYLDL(2) | CGYLDH(2) |
| Electricity consumption | CGYLDL(3) | CGYLDH(3) |
| Refinery gas yield | CGYLDL(5) | CGYLDH(5) |
| Propane yield | CGYLDL(6) | CGYLDH(6) |
| Propylene yield | CGYLDL(7) | CGYLDH(7) |
| Isobutane yield | CGYLDL(8) | CGYLDH(8) |
| Normal butane yield | CGYLDL(9) | CGYLDH(9) |
| Butylene yield | CGYLDL(10) | CGYLDH(10) |
| Cracked gasoline | CGYLDL(37) | CGYLDH(37) |
| Light cycle oil | CGYLDL(38) | CGYLDH(38) |
| Cracker bottoms | CGYLDL(39) | CGYLDH(39) |

per barrel of coker gas oil feed

| | | |
|-------------------------|------------|------------|
| Steam consumption | CCYLDL(1) | CCYLDH(1) |
| Fuel consumption | CCYLDL(2) | CCYLDH(2) |
| Electricity consumption | CCYLDL(3) | CCYLDH(3) |
| Refinery gas yield | CCYLDL(5) | CCYLDL(5) |
| Propane yield | CCYLDL(6) | CCYLDH(6) |
| Propylene yield | CCYLDL(7) | CCYLDH(7) |
| Isobutane yield | CCYLDL(8) | CCYLDH(8) |
| Normal butane yield | CCYLDL(9) | CCYLDH(9) |
| Butylene yield | CCYLDL(10) | CCYLDH(10) |
| Cracked gasoline | CCYLDL(37) | CCYLDH(37) |
| Light cycle oil | CCYLDL(38) | CCYLDH(38) |
| Cracker bottoms | CCYLDL(39) | CCYLDH(39) |

CONVL Low Catalytic Cracker conversion -- volume
percent of gas oil disappearance.

CONVH High Catalytic Cracker conversion -- volume
percent of gas oil disappearance

Thermal Cracker Yields

per barrel of vacuum gas oil feed

| | |
|-------------------------|------------|
| Steam consumption | TCCYLD(1) |
| Fuel Consumption | TCCYLD(2) |
| Electricity consumption | TCCYLD(3) |
| Refinery gas yield | TCCYLD(5) |
| Propane yield | TCCYLD(6) |
| Propylene yield | TCCYLD(7) |
| Isobutane yield | TCCYLD(8) |
| Normal Butane yield | TCCYLD(9) |
| Butylene yield | TCCYLD(10) |
| Cracked gasoline | TCCYLD(37) |
| Thermal fuel | TCCYLD(52) |

Alkylation Unit Yields

per barrel of butylene feed

| | |
|-------------------------|------------------------------------|
| Steam consumption | ALYLD(1) |
| Fuel consumption | ALYLD(2) |
| Electricity consumption | ALYLD(3) |
| Iso Butane consumption | ALYLD(8) (Enter a negative number) |
| Light Alkylate yield | ALYLD(21) |
| Heavy Alkylate yield | ALYLD(22) |

Polymerization Unit Yields

| | <u>per barrel of butylene feed</u> | <u>per barrel of propylene feed</u> |
|-------------------------|--|---|
| Steam consumption | POYLDB(1) | POYLDP(1) |
| Fuel consumption | POYLDB(2) | POYLDP(2) |
| Electricity consumption | POYLDB(3) | POYLDP(3) |
| Normal butane yield | POYLDB(9) | POYLDP(9) |
| Polymer gasoline yield | POYLDB(23) | POYLDP(23) |

Middle Distillate Desulfurizer Yields

| | <u>per barrel of diesel feed</u> | <u>per barrel of light cycle oil feed</u> |
|----------------------------|--------------------------------------|---|
| Steam consumption | DDYLDD(1) | DDYLDL(1) |
| Fuel consumption | DDYLDD(2) | DDYLDL(2) |
| Electricity consumption | DDYLDD(3) | DDYLDL(3) |
| Hydrogen consumption* | DDYLDD(4) | DDYLDL(4) |
| Refinery gas yield | DDYLDD(5) | DDYLDL(5) |
| Desulfurized product yield | DDYLDD(41) | DDYLDL(40) |
| Gasoline yield | DDYLDD(45) | DDYLDL(45) |

Gas Oil Desulfurizer Yields

| | <u>per barrel of vacuum gas oil</u> | <u>per barrel of total coker gas oil</u> |
|----------------------------|---|--|
| Steam consumption | GDYLDG(1) | GDYLDC(1) |
| Fuel consumption | GDYLDG(2) | GDYLDC(2) |
| Electricity consumption | GDYLDG(3) | GDYLDC(3) |
| Hydrogen consumption* | GDYLDG(4) | GDYLDC(4) |
| Refinery gas yield | GDYLDG(5) | GDYLDC(5) |
| Distillate product yield | GDYLDG(43) | GDYLDC(46) |
| Desulfurized gas oil yield | GDYLDG(44) | GDYLDC(47) |

* Enter a negative number for hydrogen in all processes where hydrogen is consumed.

Middle Distillate Hydrocracker Yields

| | <u>per barrel of diesel feed</u> | <u>per barrel of light cycle oil feed</u> |
|-------------------------|--------------------------------------|---|
| Steam consumption | DHYLDD(1) | DHYLDL(1) |
| Fuel consumption | DHYLDD(2) | DHYLDL(2) |
| Electricity consumption | DHYLDD(3) | DHYLDL(3) |
| Hydrogen consumption* | DHYLDD(4) | DHYLDL(4) |
| Refinery gas yield | DHYLDD(5) | DHYLDL(5) |
| Propane yield | DHYLDD(6) | DHYLDL(6) |
| Iso Butane yield | DHYLDD(8) | DHYLDL(8) |
| Normal Butane yield | DHYLDD(9) | DHYLDL(9) |
| Pentanes yield | DHYLDD(13) | DHYLDL(13) |
| Hydrocrackate yield | DHYLDD(14) | DHYLDL(14) |

Gas Oil Hydrocracker Yields

| | <u>per barrel of vacuum gas oil feed</u> | | <u>per barrel of total coker gas oil feed</u> | |
|---------------------------|--|----------------------------|---|----------------------------|
| | <u>Gasoline Mode</u> | <u>Distillate Mode</u> | <u>Gasoline Mode</u> | <u>Distillate Mode</u> |
| Steam consumption | GGYLDG(1) | GMYLDG(1) | GGYLDC(1) | GMYLDC(1) |
| Fuel consumption | GGYLDG(2) | GMYLDG(2) | GGYLDC(2) | GMYLDC(2) |
| Electricity consumption | GGYLDG(3) | GMYLDG(3) | GGYLDC(3) | GMYLDC(3) |
| Hydrogen consumption* | GGYLDG(4) | GMYLDG(4) | GGYLDC(4) | GMYLDC(4) |
| Refinery fuel gas yield | GGYLDG(5) | GMYLDG(5) | GGYLDC(5) | GMYLDC(5) |
| Propane yield | GGYLDG(6) | GMYLDG(6) | GGYLDC(6) | GMYLDC(6) |
| Iso Butane yield | GGYLDG(8) | GMYLDG(8) | GGYLDC(8) | GMYLDC(8) |
| Normal Butane yield | GGYLDG(9) | GMYLDG(9) | GGYLDC(9) | GMYLDC(9) |
| Light Hydrocrackate yield | GGYLDG(15) | GMYLDG(15) | GGYLDC(15) | GMYLDC(15) |
| Heavy Hydrocrackate yield | GGYLDG(14) | GMYLDG(14) | GGYLDC(14) | GMYLDC(14) |
| Distillate yield | GGYLDG(17) | GMYLDG(17) | GGYLDC(48) | GMYLDC(48) |

* Enter a negative number for hydrogen in all processes where hydrogen is consumed.

Catalytic Reformer Yields

per barrel of naththa feed

| | <u>@ Low Severity</u> | <u>@ High Severity</u> |
|-----------------------------------|-----------------------|------------------------|
| Steam consumption | RYLDLN(1) | RYLDHN(1) |
| Fuel consumption | RYLDLN(2) | RYLDHN(2) |
| Electricity consumption | RYLDLN(3) | RYLDHN(3) |
| Hydrogen yield* | RYLDLN(4) | RYLDHN(4) |
| Refinery gas yield | RYLDLN(5) | RYLDHN(5) |
| Propane yield | RYLDLN(6) | RYLDHN(6) |
| Iso Butane yield | RYLDLN(8) | RYLDHN(8) |
| Normal Butane yield | RYLDLN(9) | RYLDHN(9) |
| Light Platformate yield | RYLDLN(18) | RYLDHN(18) |
| Heavy Platformate yield | RYLDLN(19) | RYLDHN(19) |
| C-5, C-6 Feed Prep yield | RYLDLN(12) | RYLDHN(12) |
| Heavy-Naptha (Feed Prep yield) | RYLDLN(16) | RYLDHN(16) |

For Heavy hydrocrackate reformer feed, use the same input sequence but with RYLDLH() and RYLDHH().

For Heavy coker or visbreaker naphtha reformer feed, use the same input sequence but with RYDLCL() and RYLDHC().

RONLOW The debutanized total platformate clear research octane number corresponding to low reformer severity.

RONHI The debutanized total platformate clear research octane number corresponding to high reformer severity.

Hydrogen Plant Yields

| | <u>per barrel FOE from refinery gas</u> | <u>per liquid bbl from propane</u> |
|-------------------------|---|--|
| Steam consumption | HYYLDG(1) | HYYLDP(1) |
| Fuel consumption | HYYLDG(2) | HYYLDP(2) |
| Electricity consumption | HYYLDG(3) | HYYLDP(3) |
| Hydrogen production** | HYYLDG(4) | HYYLDP(4) |

* Enter a positive number here in barrels FOE hydrogen per barrel of feed stream (95% pure hydrogen) since there is a production rather than a consumption of hydrogen.

** A positive number.

Butane Isomerizer

per barrel normal butane feed

| | |
|-------------------------|-----------|
| Steam consumption | BIYLD(1) |
| Fuel consumption | BIYLD(2) |
| Electricity consumption | BIYLD(3) |
| Refinery gas yield | BIYLD(5) |
| Propane yield | BIYLD(6) |
| Iso Butane yield | BIYLD(8) |
| Pentanes yield | BIYLD(11) |

Petroleum Kerosene Hydrotreater Yields

per barrel of kerosene feed

| | |
|-----------------------------|-----------|
| Steam consumption | HKYLD(1) |
| Fuel consumption | HKYLD(2) |
| Electricity consumption | HKYLD(3) |
| Hydrogen consumption | HKYLD(4) |
| Refinery gas yield | HKYLD(5) |
| Hydrotreater gasoline yield | HKYLD(45) |
| Hydrotreater kerosene | HKYLD(50) |

Shale Oil Kerosene Hydrotreater Yields

| | <u>per bbl of light kerosene feed (400 to 525°F EP)</u> | <u>per bbl of heavy kerosene feed (525 to 650°F EP)</u> |
|-------------------------|---|---|
| | <u>Low Severity</u> | <u>Low Severity</u> |
| Steam consumption | SSKYL1(1)* | SSKYH1(1)* |
| Fuel consumption | SSKYL1(2) | SSKYH1(2) |
| Electricity consumption | SSKYL1(3) | SSKYH1(3) |
| Hydrogen consumption* | SSKYL1(4) | SSKYH1(4) |
| Refinery fuel gas yield | SSKYL1(5) | SSKYH1(5) |
| Hydrotreated kerosene | SSKYL1(58) | SSKYH1(59) |

* Note: For intermediate and high severity operations, replace the numeral 1 (i.e., the sixth character) by 2 or 3, respectively.

Coal Oil Kerosene Hydrotreater Yields

| | per bbl of light kerosene feed (400 to 525°F EP) | per bbl of heavy kerosene feed (525 to 650°F EP) |
|-------------------------|--|--|
| | <u>Low Severity</u> | <u>Low Severity</u> |
| Steam consumption | COKYL1(1)* | COKYH1(1)* |
| Fuel consumption | COKYL1(2) | COKYH1(2) |
| Electricity consumption | COKYL1(3) | COKYH1(3) |
| Hydrogen consumption** | COKYL1(4) | COKYH1(4) |
| Refinery fuel gas yield | COKYL1(5) | COKYH1(5) |
| Hydrotreated kerosene | COKYL1(64) | COKYH1(65) |

Shale and Coal Oil for Oil Hydrocrackers

| | <u>Shale Oil</u> | <u>Coal Oil</u> |
|--|---------------------|---------------------|
| | <u>Low Severity</u> | <u>Low Severity</u> |
| Steam consumption | SSGY1(1)* | COGY1(1)* |
| Fuel consumption | SSGY1(2) | COGY1(2) |
| Electricity consumption | SSGY1(3) | COGY1(3) |
| Hydrogen consumption* | SSGY1(4) | COGY1(4) |
| Refinery fuel gas yield | SSGY1(5) | COGY1(5) |
| Propane yield | SSGY1(6) | COGY1(6) |
| Isobutane yield | SSGY1(8) | COGY1(8) |
| N-butane yield | SSGY1(9) | COGY1(9) |
| Light hydrocrackate (250°F EP) | SSGY1(15) | COGY1(15) |
| Heavy hydrocrackate (400°F EP) | SSGY1(14) | COGY1(14) |
| Light hydrotreated kerosene (400° - 525°F EP) | SSGY1(58) | COGY1(64) |
| Heavy hydrotreated kerosene (525° - 650°F EP) | SSGY1(59) | COGY1(65) |
| Hydrotreated gas oil (650°F +) | SSGY1(60) | COGY1(66) |

* Note: For intermediate and high severity operations, replace the numeral 1 (i.e., the fifth character) by 2 or 3, respectively.

3.2.5 Intermediate Stream Properties

The following input variables relate to the properties of the individual streams which are yielded from the various refinery process units. They are not required as input unless it is desired to replace the data base values contained within the program. Input items described

** Enter a negative number.

in this section are included between the headers &UDATA and &END, except for viscosity (VIS or V) and octane (OC) properties, which are included between &UDATA1 and &END.

For aviation turbine fuel and fuel oil blending components the properties include the API gravity, sulfur content, nitrogen content and the viscosity blending index value. Hydrogen contents are calculated from a correlation of specific gravity and mid-boiling points except for select streams where a hydrogen content may be specified to override the calculated value. Gasoline blending component properties also include the Research (blending) Octane Number for 0 and 3 ml of TEL.

The viscosity blending numbers used must correspond to Saybolt Seconds at 210 degrees Fahrenheit so that they are consistent with the values contained in the model. A viscosity conversion chart is attached as Exhibit 6.

With the exceptions to be noted, the input variables are all elements of real arrays. The butane blending octane numbers are (non-array) real numbers.

A consistent logic applies to the naming of intermediate stream properties. This logic is illustrated below using the kerosene hydro-treater unit as an example:

| <u>Description</u> | <u>Array</u> | <u>Remarks</u> |
|-----------------------|--------------|---|
| Yield Array | HKYLD(I) | See section 2.2.4 for details. |
| API Gravity | HKAPI(I) | For pentanes and heavier streams. |
| Sulfur Distribution | HKSUL(I) | Fractional sulfur distribution among products.* |
| Nitrogen Distribution | HKNIT(I) | Fractional nitrogen distribution among products.* |

* These should add to 1.0, unless there are external losses, such as loss of sulfur from the combustion of catalytic coke.

| | | |
|---|----------|-----------------------------------|
| Hydrogen Content | HKHYD(I) | Hydrogen content, wt. % |
| Viscosity Blending Number (input between &UDATA1 and &END) | HKVIS(I) | For kerosene and heavier streams. |

The above logic is used to name the properties of streams for all of the process units using the three-character set YLD and which are enumerated in Section 3.2.4. The character set YLD is replaced by API, SUL, NIT, HYD or VIS to input the appropriate property. The letter "I" shown under the heading Array refers to the stream identification number provided in Section 3.2.4 for process units employing a single character to describe the yield array. The letter Y is replaced by A, S, N and H to input API, sulfur distribution, nitrogen distribution and hydrogen content, respectively, for units employing a single character. These are listed below:

| <u>Unit</u> | <u>Array</u> |
|----------------------------------|--------------|
| Shale Oil Kerosene Hydrotreater | |
| Low Severity - Light Kerosene | SSKYL1(I) |
| Medium Severity - Light Kerosene | SSKYL2(I) |
| High Severity - Light Kerosene | SSKYL3(I) |
| Low Severity - Heavy Kerosene | SSKYH1(I) |
| Medium Severity - Heavy Kerosene | SSKYH2(I) |
| High Severity - Heavy Kerosene | SSKYH3(I) |
| Coal Oil Kerosene Hydrotreater | |
| Low Severity - Light Kerosene | COKYL1(I) |
| Medium Severity - Light Kerosene | COKYL2(I) |
| High Severity - Light Kerosene | COKYL3(I) |
| Low Severity - Heavy Kerosene | COKYH1(I) |
| Medium Severity - Heavy Kerosene | COKYH2(I) |
| High Severity - Heavy Kerosene | COKYH3(I) |
| Shale Oil Gas Oil Hydrocracker | |
| Low Severity | SSGY1(I) |
| Medium Severity | SSGY2(I) |
| High Severity | SSGY3(I) |
| Coal Oil Gas Oil Hydrocracker | |
| Low Severity | COGY1(I) |
| Medium Severity | COGY2(I) |
| High Severity | COGY3(I) |

For those processing units, viscosity is expressed as non-array real numbers.

| <u>Unit</u> | <u>Variable</u> |
|---------------------------------|-----------------|
| Shale Oil Kerosene Hydrotreater | |
| Light Kerosene | SSKVL1 |
| Heavy Kerosene | SSKVH1 |
| Shale Oil Gas Oil Hydrocracker | |
| Light Kerosene | SSGVL1 |
| Heavy Kerosene | SSGVH1 |
| Fuel Oil | SSGVG1 |

For the coal oil viscosities corresponding to the above, replace SS with CO.

Hydrogen content of streams may be input only for certain process units -- generally those units which yield some portion of their product directly into aviation turbine fuel blends. If values are not input, the hydrogen content is calculated from a generalized correlation employing specific gravity and mid-boiling point. For units not listed below, hydrogen content may not be specified and the correlation results may not be overridden by input specification.

List of Units for Which Product
Stream Hydrogen Contents May be Specified

| <u>Unit</u> | <u>Array Name</u> |
|--|-------------------|
| Distillate desulfurizer (petroleum) | |
| Straight run stock | DDHYDD(I) |
| FCC light cycle oil | DDHYDL(I) |
| Light coker/visbreaker gas oil | DDHYDC(I) |
| Gas Oil hydrocracker (petroleum) | |
| Straight run stock-gasoline mode | GGHYDG(I) |
| Coker/visbreaker stock-gasoline mode | GGHYDC(I) |
| Straight run stock-distillate mode | GMHYDG(I) |
| Coker/visbreaker stock-distillate mode | GMHYDC(I) |
| Kerosene hydrotreater (petroleum) | HKHYD(I) |

| <u>Unit</u> | <u>Low Severity</u> | <u>Medium Severity</u> | <u>High Severity</u> |
|--|-------------------------|----------------------------|--------------------------|
| Shale oil light kerosene hydrotreater | SSKHL1(I) | SSKHL2(I) | SSKHL3(I) |
| Shale oil heavy kerosene hydrotreater | SSKHH1(I) | SSKHH2(I) | SSKHH3(I) |

| | | | |
|---|-----------|-----------|-----------|
| Coal oil light kerosene hydrotreater | COKHL1(I) | COKHL2(I) | COKHL3(I) |
| Coal oil heavy kerosene hydrotreater | COKHH1(I) | COKHH2(I) | COKHH3(I) |
| Shale oil gas oil hydrocracker | SSGH1(I) | SSGH2(I) | SSGH3 (I) |
| Coal oil gas oil hydrocracker | COGH1(I) | COGH2(I) | COGH3 (I) |

Input variable specification for gasoline blending component streams are given below (note that butane values are non-array). All these quantities are input in between &UDATA1 and &END.

| | Research Octane Number | |
|---|------------------------|-------------|
| | @ 0 ml. TEL | @ 3 ml. TEL |
| Butanes | C4OCL | C4OCH |
| Reformer Feed Prep C5/C6 | ROCLD(12) | ROCHD(12) |
| Mid. Dist. Hydrocracker C5's | DHOCL(13) | DHOCH(13) |
| Gas Oil Hydrocracker-Light Hydrocrackate | GGOCL(15) | GGOCH(15) |
| Crude Unit Straight Run Gasoline (incl. C5's) | CUOCL(24) | CUOCH(24) |
| Cracker Gasoline (Full range) | | |
| From vacuum gas oil at low conversion* | CGOCLL(37) | CGOCHL(37) |
| From vacuum gas oil at high conversion | CGOCLH(37) | CGOCHH(37) |
| From coker gas oil at low conversion | CCOCLL(37) | CCOCHL(37) |
| From coker gas oil at high conversion | CCOCLH(37) | CCOCHH(37) |
| Visbreaker/Coker light gasoline** | COOCLL(31) | COOCHL(31) |
| Light Alkylate | ALOCL(21) | ALOCH(21) |
| Heavy Alkylate | ALOCL(22) | ALOCH(22) |
| Polymer gasoline | POOCL(23) | POOCH(23) |
| Light platformate-low severity | ROCLLL(18) | ROCHLL(18) |
| Light platformate-high severity | ROCLHL(18) | ROCHHL(18) |
| Heavy platformate-high severity | ROCLLH(19) | ROCHLH(19) |
| Heavy platformate-high severity | ROCLHH(19) | ROCHHH(19) |
| Desulfurizer Overhead Gasoline | DDOCL(45) | DDOCH(45) |

* Uses the low conversion input variables for a thermal gas oil cracker.

** For 250°F EP light gasoline (below reforming range) produced from vacuum bottoms coking or visbreaking.

3.2.6 Miscellaneous Stream Quality Factors

The following input variables pertain to quality factors which relate the properties of refinery process unit product streams to the properties of their input streams. They are not required as input unless it is desired to replace the data base values contained within the program. All input variables are real numbers (non-arrays). All input items in this section are included between input header cards &UDATA1 and &END.

The following are API gravity differentials between the indicated product stream and the process unit feed.

| <u>Quality Variable</u> | <u>Description</u> |
|-------------------------|--|
| DAHKG* | API of gasoline minus kerosene hydrotreater feed (petroleum) |
| DAHKK* | API of treated kerosene minus kerosene hydrotreater feed (petroleum) |
| DAVBLG | API of visbreaker light gasoline minus vacuum bottoms feed |
| DAVBHG | API of visbreaker heavy gasoline minus vacuum bottoms feed |
| DAVBGO | API of visbreaker gas oil minus vacuum bottoms feed |
| DAVBPH | API of visbreaker pitch minus vacuum bottoms feed |
| DACOLG | API of coker light gasoline minus vacuum bottoms feed |
| DACOHG | API of coker heavy gasoline minus vacuum bottoms feed |
| DATCG | API of thermal cracker gasoline minus gas oil feed |
| DATCTF | API of thermal cracker thermal fuel minus gas oil feed |
| DACCG | API of catalytic cracker gasoline minus gas oil feed |
| DACCL | API of catalytic cracker light cycle oil minus gas oil feed |
| DACCS | API of catalytic cracker bottoms product minus gas gas oil feed |

* Light Kerosene: 400 to 525°F boiling range

| <u>Quality Variable</u> | <u>Description</u> |
|-------------------------|--|
| DADDD** | API of desulfurized distillate minus distillate desulfurizer feed (petroleum) |
| DADDG** | API of gasoline product minus distillate desulfurizer feed (petroleum) |
| DAGDG | API of gasoline product minus gas oil desulfurizer feed (petroleum) |
| DAGDD | API of distillate product minus gas oil desulfurizer feed (petroleum) |
| DAGDGO | API of treated gas oil product minus coker gas oil desulfurizer feed. |
| DAGGO | API of treated gas oil product minus straight run gas oil desulfurizer feed (petroleum) |
| DADHH | API of heavy hydrocrackate (250 to 400°F) minus distillate hydrocracker feed |
| DAHLYK | API of light hydrocrackate minus gas oil hydrocracker feed (in gasoline mode) |
| DAHYHK | API of heavy hydrocrackate minus gas oil hydrocracker feed (in gasoline mode) |
| DAHMYL | API of light hydrocracker minus gas oil hydrocracker feed (in middle distillate mode) |
| DAHMH | API of heavy hydrocrackate minus gas oil hydrocracker feed (in middle distillate mode) |
| DAHMYL | API of light kerosene (400 to 525°F) minus gas oil hydrocracker feed (distillate operation). |
| DAHMYH | API of heavy kerosene (525 to 650°F) minus gas oil hydrocracker feed (distillate operation). |

** Heavy Kerosene: 525 to 650°F boiling range.

SHALE AND COAL OIL PROCESSING

| | Shale Oil Kerosene Hydrotreater | | | Coal Oil Kerosene Hydrotreater | | | | | | | | |
|--|---------------------------------|--------|--------|---------------------------------|--------|--------|--------|--------|--------|--------|--------|--------|
| | Light Kerosene Product Severity | | | Light Kerosene Product Severity | | | | | | | | |
| | Low | Medium | High | Low | Medium | High | | | | | | |
| API Product kerosene minus feed | DASKL1 | DASKL2 | DASKL3 | DASKH1 | DASKH2 | DASKH3 | DACKL1 | DACKL2 | DACKL3 | DACKH1 | DACKH2 | DACKH3 |
| | DASKLS | DASKLS | DASKLS | DASKHS | DASKHS | DASKHS | DACKLS | DACKLS | DACKLS | DACKHS | DACKHS | DACKSH |
| Fractional Change in Paraffin content* | DPNLKS | | | DPNHKS | | | DPNLKC | | | DPNHKC | | |
| | DARLKS | | | DARHKS | | | DARLKC | | | DARHKC | | |
| Change in Freezing Point* | DFRLKS | | | DRFHKS | | | DFRLKC | | | DRFHKC | | |

* These inputs determine the changes in light kerosene (400 to 525°F) and heavy kerosene (525 to 650°F) properties and should be values which are consistent with the hydrotreating option being specified. As an example, an input of 1.05 for DPNLKS would result in a hydrotreated light kerosene paraffin content 1.05 times that of the shale oil light kerosene feed, an input of .8 for DARLKS results in a product aromatics content of 0.8 times that of the feed. The product naphthene content is calculated by the program by difference. An input of -30.0 for DFRLKS would lower the freezing point of the hydrotreated light kerosene product by 30°F below that of the light kerosene feed.

| | <u>Shale Oil</u> <u>Gas Oil Hydrocracking</u> | | <u>Coal Oil</u> <u>Gas Oil Hydrocracking</u> | |
|--|---|---|---|---|
| | <u>Light</u> <u>Kerosene</u> <u>Product</u> <u>(400-525°F)</u> | <u>Heavy</u> <u>Kerosene</u> <u>Product</u> <u>(525-650°F)</u> | <u>Light</u> <u>Kerosene</u> <u>Product</u> <u>(400-525°F)</u> | <u>Heavy</u> <u>Kerosene</u> <u>Product</u> <u>(525-650°F)</u> |
| Paraffin Content (WT%)* | PNHLKS | PNHHKS | PNHLKC | PNHHKC |
| Aromatic Content (WT%) | ARHLKS | ARHHKS | ARHLKC | ARHHKC |
| Naphthene Content (WT%) | NAHLKS | NAHHKS | NAHLKC | NAHHKC |
| Freezing Point (°F)* | FRHLKS | FRHHKS | FRHLKC | FRHHKC |
| <u>API Difference</u> <u>Between Product</u> <u>and Gas Oil Feed</u> | | | | |
| Gas Oil | | | | |
| - Low Severity | | DASHG1 | | DACHG1 |
| - Medium Severity | | DASHG2 | | DACHG2 |
| - High Severity | | DASHG3 | | DACHG3 |
| Kerosene | | | | |
| - Low severity | DASHL1 | DASHH1 | DACHL1 | DACHH1 |
| - Medium severity | DASHL2 | DASHH2 | DACHL2 | DACHH2 |
| - High severity | DASHL3 | DASHH3 | DACHL3 | DACHH3 |
| Light Gasoline (250°F EP)* | | DASHLG | | DACHLG |
| Heavy Gasoline (250-400°F) | | DASHHG | | DACHHG |

* Make these inputs consistent with the specified severity.

PETROLEUM PROCESSING

| | <u>Kerosene Hydrotreater (400 to 525°F)</u> | <u>Distillate Hydrotreater (525 to 650°F)</u> |
|---|---|---|
| Fractional Change in Paraffin Content | DPNLKP | DPNHKP |
| Fractional Change in Aromatic Content | DARLKP | DARHKP |
| Change in Freezing Point (°F) | DFRLKP | DFRHKP |
| API difference, gasoline product minus feed | DAHKG | DADDG |
| API difference treated kerosene or distillate minus feed | DAHKK | DADDD |

| | <u>Petroleum Gas</u> | <u>Oil Hydrocracker</u> |
|--|------------------------------------|--------------------------------------|
| | <u>Gasoline Mode Operation</u> | <u>Distillate Mode Operation</u> |
| Light Hydrocrackate Product (IBP to 250°F)* | DAHYLK | DAHMYL |
| Heavy Hydrocrackate Product (250 to 400°F)* | DAHYHK | DAHMYH |
| Light Kerosene Product (400 to 525°F)** | | |
| API kerosene product minus gas oil feed | - | DAHYKL |
| Paraffin content, wt% | - | PNHLKP |
| Napthene content, wt% | - | NAHLKP |
| Aromatics content, wt% | - | ARHLKP |
| Freezing Point, °F | - | FRHLKP |
| Heavy kerosene product (525 to 650°F)** | | |
| API kerosene product minus gas oil feed | - | DAHYKH |
| Paraffin content, wt% | - | PNHHKP |
| Napthene content, wt% | - | NAHHKP |
| Aromatics content, wt% | - | ARHHKP |
| Freezing Point, °F | - | FRHHKP |

* API gravity of gasoline range products minus the gas oil feed

** Kerosene products are not yielded in gasoline mode operation.

3.2.7 Purchased Blending Stocks and Fixed Product Sales

The following input variables relate to the use of segregated refinery blending stocks. Values must be input if any of these segregated feed stocks are used since of course no default values are contained within the program. These streams are used directly for blending and are not "processed" in the refinery. All input in this section must be included between the &PDATA and &END header cards.

| <u>Variable</u> | <u>Description</u> |
|-----------------|--|
| PKERO (1) | Volume (BPD) of segregated kerosene stock (400 to 525°F). |
| PKERO (2) | API of segregated kerosene stock. |
| PKERO (3) | Sulfur content of segregated kerosene stock, wt percent. |
| PKERO (4) | Viscosity of segregated kerosene stock, viscosity blending index at 210°F. |
| PKERO (5) | Nitrogen content of segregated kerosene stock, wt percent. |
| PKERO (6) | Hydrogen content of segregated kerosene stock, wt percent. |
| PKERO (7) | Paraffin content of segregated kerosene stock, wt percent. |
| PKERO (8) | Naphthene content of segregated kerosene stock, wt. percent. |
| PKERO (9) | Aromatics content of segregated kerosene stock, wt percent. |
| PKERO (10) | Freezing point of segregated kerosene stock, °F. |
| PKERO (11) | Smoke point of segregated kerosene stock, millimeters. |
| PKERO (12) | Heat of combustion of segregated kerosene stock, BTU per pound. |

The input logic is identical for purchased heavy kerosene or diesel cut (500 to 650°F), purchased gas oil (650 to 1050°F) and purchased residuum (1050°F +). The corresponding array names are, respectively:

PDSL (I)
PGOIL (I)
PRSD (I)

There is provision in the program for fixed product sales of light and heavy kerosene (diesel) and gas oil. The symbolic variable names are given below.

| <u>Name</u> | <u>Type</u> | <u>Units</u> | <u>Description</u> |
|-------------|-------------|--------------|---|
| KERO | Real | BPD | The external sale of the refinery light kerosene stream. If there is a kerosene hydrotreater, it is assumed that the hydrotreated kerosene stream is being sold. Boiling range is 400 to 525°F. |
| DIESEL | Real | BPD | The external sale of the refinery diesel oil (heavy kerosene) stream. If there is a middle distillate desulfurizer, it is assumed that the desulfurized diesel stream is sold. Boiling range is 525 to 650°F. |
| GASOIL | Real | BPD | The external sale of the refinery vacuum gas oil stream (untreated). Boiling range is 650 to 1050°F. |

3.2.8 Aviation Turbine Fuel and Fuel Oil Blend Specifications

The following input variables relate to the establishment of aviation-turbine fuel blend specifications. If the hydrogen content specification is

omitted, the program will bypass blend calculations for determining the maximum quantity of fuel available of a fixed hydrogen content. If the endpoint specification is omitted, a default value of 588°F will be assumed midway between the 525 and 650°F distillation temperature for which blend component yields and properties are contained in the program data bases. All of the variables listed below are real numbers. All information in this section must be included between the &PDATA and &END header cards.

| <u>Blend Variable</u> | <u>Description</u> |
|-----------------------|--|
| HDSPEC | The aviation turbine fuel hydrogen content in weight percent. |
| EPSPEC | The ASTM D-86 endpoint in °F specified for the jet fuel blend (this blend is calculated in addition to the 525 and 650°F endpoint blends, which are calculated as a matter of course). |

The following variables relate to the establishment of middle distillate and residual fuel oil blend specifications. If they are not input, as will usually be the case if aviation turbine fuel blending is the prime concern, the program will simply calculate and report the volumes and properties of the remaining total middle distillate and residual fuel oil pools. The following variables must be input if additional fuel oil pool calculations are desired to meet any particular specifications. All of the variables are real numbers.

| <u>Blend Variable</u> | <u>Description</u> |
|-----------------------|--|
| SPECMD | The program will calculate and report the maximum volume of middle distillate range fuel oil of the specified <u>sulfur content</u> available from the entire middle distillate fuel oil pool. |

SPECRF

The program will calculate and report the maximum volume of residual fuel oil of the specified sulfur content available from the entire residual fuel oil pool.

SPM1, VM1
SPM2, VM2

These input variables refer to the sulfur contents (SPM1, SPM2) and BPD volumes (VM1, VM2) of fixed middle distillate range fuel oil requirements. Either one or two fixed blends may be specified. The program will calculate the composition and properties of these blends and will blend the excess middle distillate components into the residual fuel oil pool.

SPR1, VR1
SPR2, VR2

These are input variables corresponding to the above, but which refer to the residual fuel oil pool. The program will calculate the composition and properties of these residual fuel oil blends, along with the composition, volume, and properties of the remaining residual fuel oil pool after the specified fixed blends have been subtracted out.

3.2.9 Report Options and Economic Data

The following report options are available for specifying the type and quantity of output reports:

| | | |
|------|---------|--|
| IREP | Integer | IREP=1, Summary reports and fuel blending reports only. This option excludes the refinery economic summary report. This is the default option; IREP=2, the above reports, plus the refinery economic summary report; IREP=3, all reports, including material and sulfur, nitrogen, hydrogen balances for each of the refinery process units. |
|------|---------|--|

Economic Inputs

These are required only if report options IREP=2 or 3 are in force.

Each of the input items entering into the economic calculation are specified below. Required items are listed first, followed by those which are optional

because of the inclusion of corresponding values within the program data base. Economics related data base values are given in Exhibit 7. All information in this section must be included between the &PDATA and &END header cards.

Required Inputs

| <u>Symbolic Name</u> | <u>Type</u> | <u>Units</u> | <u>Description</u> |
|--------------------------|----------------|---|--|
| STRF | Real Number | Fraction | Average refinery stream day factor. Fraction of time that the refinery is not down for maintenance or emergency repair. |
| PDBBL (1) | Real Array | dollars per barrel fuel oil equivalent (FOE) | Refinery netback price for fuel gas |
| PDBBL (2) | " | dollars per liquid barrel @ 60°F | Refinery netback price for LPG sales. |

| <u>Symbolic Name</u> | <u>Type</u> | <u>Units</u> | <u>Description</u> |
|----------------------|-------------|---|--|
| PDBBL (3) | Real Array | dollars per liquid barrel @ 60°F. | Refinery netback price for naptha export. |
| PDBBL (4) | " | " | Refinery netback price for refinery kerosene sale (if any). |
| PDBBL (5) | " | " | Refinery netback price for refinery diesel sale (if any). |
| PDBBL (6) | " | " | Refinery netback price for refinery gas oil sale (if any). |
| PDBBL (7) | " | " | Refinery netback price for the total gasoline pool produced. |
| PDBBL (8) | " | " | Refinery netback price for the specified aviation turbine fuel blend. |
| PDBBL (9) | " | " | Refinery netback price for middle distillate fuel oil. |
| PDBBL (10) | " | " | Refinery netback for residual fuel oil. |
| DPBBL (I) | " | dollar per liquid barrel @ 60°F | Crude oil cost, where index I refers to the crude oil to be given in Exhibit 4, List of Data Base Crude Oils. If crudes outside of the data base are specified, the codes should correspond to those used for the newly specified crude oils. |
| PFPR | real number | dollars per barrel of fuel oil equivalent (FOE) | The price assigned to fuel required to meet the internal refinery fuel needs. If these are to be diverted from potential refinery fuel oil or gas sales, then the refinery netback price for these may be used. If outside fuel purchases are required, then the purchase price may apply. |
| CENTKW | Real number | cents per kilowatt hour. | The refinery power purchase cost. |
| UNTMP (I) | " | Percent | The percentage of investment cost to be taken for fixed annual maintenance costs for the specified process unit. The index I refers to the process unit identifier given in Exhibit 5 and is used to specify the unit. |

| | | | |
|------------|-------------|----------------------------|---|
| UNTV (I)* | " | dollars per barrel of feed | Process unit variable operating costs. |
| UNTLC (I)* | " | dollars per day. | Process unit fixed labor costs |
| IVESTC | Real number | Fraction | The annualized refinery investment carrying charge, expressed on a fraction rather than a percentage. This carrying charge usually includes the cost of capital, local taxes, and plant depreciation. |

Optional Inputs (Values are contained in the program data base)

| <u>Symbolic Name</u> | <u>Type</u> | <u>Units</u> | <u>Description</u> |
|----------------------|-------------|---|--|
| UNTCPC (I)* | Real array | dollars per barrel per day (\$ per BPD of feed) | Process unit capacity cost corresponding to the unit size, input below. |
| UNTSTR (I)* | " | BPD | The unit size for which the process unit cost is given. |
| UNTEXP (I) | " | dimensionless fraction | The power law exponent to be used in adjusting the process unit cost for actual plant size. The equation is: |

$$\left(\frac{I_1}{I_2}\right) = \left(\frac{C_1}{C_2}\right)^N$$

I is investment cost
C is BPD capacity and
N is the power law exponent

-
- * Exceptions are the alkylation unit, which is based on \$/BPD of alkylate product, the polymerization unit which is based on \$/BPD of polymer product and the hydrogen plant which is based on dollars per thousands of standard cubic feet per day (60° and 14.696 psia). Note also that the index I refers to the process unit identifier given in Exhibit 5.

3.3 INPUT VARIABLE DEFAULT VALUES

Input variables are given default values within the program in order to minimize the data input requirements. Please note that a subject case of a case study sequence will use the data input established in the base case, rather than revert to the original default values. For example, if a base case has a fluid catalytic cracker, FCC = 50000.0, and it is desired to study the refinery situation without the cracker, then FCC = 0.0 must be input in the subject case, rather than depending on the default value of FCC = 0.0. In brief, the base case values override the program default values.

3.3.1 Unit Throughputs

All unit throughputs are initialized to 0.0, so that if a unit is not present within a refinery configuration, no input item is required for that unit. The atmospheric crude unit capacity is calculated by the program to accommodate the total quantity of crude oil charged to the refinery. Vacuum distillation capacity, however, must be specified.

3.3.2 Unit Operations

- a) CONV = CONVH = 85.0
REFRON = RONHI = 100.0

Fluid catalytic cracker and catalytic Naphtha Reformer severities are initialized at the maximum.

- b) MODE = 1

The Gas Oil Hydrocracker is assumed to be in the gasoline production mode unless otherwise specified.

- c) SVSKHT, SVCKHT, SVSGHT, SVCGHT all = 2.

The Shale Oil and Coal Oil Kerosene Hydrotreater and Gas Oil Hydrocrackers are all initialized at medium severity.

3.3.3 Internal Stream Destinations

The default option is to prorate the volume of internal refinery streams having more than one downstream destination by the capacity of the alternative downstream process units. For example, if:

| | |
|-----------------|----------------------------------|
| GODES = 50000.0 | Gas Oil Desulfurization Capacity |
| FCC = 50000.0 | Fluid Catalytic Cracker |

then:

| | |
|--------------|--|
| VGOES = 0.5 | Fraction virgin gas oil to desulfurization |
| CGODES = 0.5 | Fraction coker gas oil to desulfurization |
| VGOFCC = 0.5 | Fraction virgin gas oil to cracker |
| CGOFCC = 0.5 | Fraction coker gas oil to cracker |

In the above, any gas oils which can not be accommodated by the process units because of restrictive capacity will automatically go to residual fuel oil blending. If the fractional disposition of a given internal refinery is less than 1.0, then the remainder will automatically be sent to final product blending, regardless of process unit capacities. For example, if the only destination for light cycle oil is desulfurization, but it is desired to send 20% directly to middle distillate fuel oil blending, then input LCODES = 0.8 and the program automatically sends the remainder to fuel oil blending.

3.3.4 Product Sales

KERO = 0.0

DIESEL = 0.0

GASOIL = 0.0

It is assumed that unless otherwise specified there are no external kerosene, diesel or gasoil sales.

3.3.5 Segregated Blending Stocks

PKERO (1) = 0.0

PDSL (1) = 0.0

PGOIL (1) = 0.0

PRSD (1) = 0.0

The volumes of purchased segregated fuel oil blending stocks (which remain unmixed with any other refinery streams prior to blending) are initialized at zero. The actual volumes and stream properties must be supplied by the program user if segregated blending stocks are desired.

3.3.6 Blend Specifications

The following blend specification values are present for aviation turbine fuel:

EPSPEC = 588.0°F

HDSPEC = 0.0

The endpoint specification default is set midway between 525 and 650°F, the ASTM temperature corresponding to blending component properties contained within the program data base. The effect of the hydrogen specification default of 0.0 is to bypass program options that blend aviation turbine fuels to a minimum hydrogen content blend specification.

The following blend specifications values are present for middle distillate and residual fuel oil blends:

SPECMD = 0.0

SPM1 = 0.0 VM1 = 0.0

SPM2 = 0.0 VM2 = 0.0

SPECRF = 0.0

SPR1 = 0.0 VR1 = 0.0

SPR2 = 0.0 VR2 = 0.0

The effect of the above zero initialization values is to make the programmed assumption that no fixed volume and sulfur content blends are to be produced, unless explicitly specified by the program user by using one or more of the above input variables. If none of the above input variables are specified, the program will simply calculate the volume and properties of the distillate and residual fuel oil pools, after jet fuel production.

3.3.7 Data Base Values

Yields, stream properties, and stream quality factors are contained within the program to approximate a typical petroleum refinery with a wide range of individual process units. In addition, crude assay data is contained within the program for a number of crude oils of world-wide importance. The full list of stored data is not presented here. The complete data base is contained in the programming documentation found in Volume III (NASA CR-135335).

Any item in the process unit and crude assay data base may be altered by the user to represent variations in process unit yields, stream qualities, and crude oil assays. This affords the model user considerable power in matching a particular petroleum refining situation.

Crude oil and process unit data base items must be changed at the beginning of the input data stream run set up and remains in force for all subsequent base and subject cases throughout the run sequence.

Separate job steps are required if it is desired to study the effect of varying the crude assay or process unit data base values. The crude oil and process unit data base files are handled by the program as permanent files throughout a run sequence once the initial changes are made at the beginning of the input card stream.

Process unit investment costs, fixed and variable operating cost information, and investment cost power law exponents are contained in the program data base (in subroutine Block Data). These values are used in the economic calculation, unless altered by the user during run sequence.

4.0 MODEL FLEXIBILITY AND LIMITATIONS

The Gordian Refinery Simulation Model was developed using the Control Data 6600 computer and has been converted to the IBM 360/67 computer. Their program requires about 225 K words of storage on the CDC 6600 computer and about 400 K bytes of storage on the IBM 360/67 computer.

The detailed model limitations are covered either explicitly or implicitly in section 3.0 (the input description) of this manual. In general, any capability not encompassed by the description of program inputs is not available to the model. The purpose of this section is to summarize the principal model limitations and flexibility aspects.

(1) The total crude data base is limited to 35 distinct crude types. The program is presently organized that 26 of these are reserved for permanent data base crudes and 9 are for crudes which the user may want to add during a particular run sequence. Petroleum based, coal based and shale oil based crude oils may be specified for refinery processing.

The word crude is used somewhat loosely. Gas oils, diesel stocks and kerosenes may also be made a part of either the permanent or temporary data base. The capability reserved for additional crude types may also be used to represent refinery purchase streams such as natural gas and butanes.

(2) An important factor in using the above refinery feed capabilities is to recognize that petroleum, coal based and shale oil based crude oils are processed through segregated crude units and hydrotreating facilities. In order to simulate the situation where segregated blending stocks are used, as many as four purchased blending stocks may be specified.

The input terminology suggests that the purchased streams are the kerosene, diesel, gas oil, and residuum types. Actually, since all of the stream properties must be supplied along with the volume rate of the feed, these streams may represent any segregated stream in general. Thus, it would be possible to specify two segregated gas oil and two segregated kerosene streams as purchase for final fuel oil blending stocks.

Any streams of the above type are not blended with any other feeds prior to being blended into their respective fuel oil pools.

(3) The refinery process units which are included in the model's process unit data base are restricted to those specified in Exhibit 5. Programming modifications are necessary to expand the allowable petroleum refinery configuration beyond its present range.

The model is flexible in allowing for diversity in the specification of the refinery configuration. For example, units using the same feed stream type such as a fluid cracker and a thermal cracker (using straight run virgin gas oil) may be included within the same refinery configuration. When dual units of this type are included, it is necessary to define the split in the feed stream between units by making use of the appropriate input variables, unless the default of prorating feeds by available capacity is desired.

(4) Aviation Turbine fuel (jet fuel blends) in the kerosene range are reported by the model. Considerable flexibility has been included in the program in order to extract the maximum useful information from a single run. The user may specify a jet fuel endpoint specification and minimum hydrogen content specification. The model will then calculate blends as 525°F, 650°F and the specified endpoint. All blends are reported on an "as made" basis and at the specified hydrogen content.

The aviation turbine fuel of specified endpoint and specified hydrogen content is calculated as the basis for the overall refinery balance, with the remaining distillate components going to distillate fuel (heating oil) blending.

(5) Up to two fixed distillate blends and two fixed residual fuel oil blends may be specified. Both sulfur content and blend volume must be specified for each fixed blend.

Each distillate blend specified is subtracted from the total distillate fuel oil pool and the volume, composition, and properties of the remaining pool are calculated by the model. Any excess middle distillate components are then blended into the residual fuel oil pool. The required residual fuel oil blends are then made and the properties of the remaining residual pool are reported.

5.0 SAMPLE PROBLEM SET-UPS

The copies of computer card input shown in Exhibit 8 illustrate the feature of the Gordian Refinery Simulation Model of handling a base case and subsequent dependent cases. The first group of images is the sample case presented in Exhibit 1. Two dependent input setups are shown for changes in jet fuel, distillate, and residual fuel outputs. Each input group represents a change only in the variables shown; all others remain at base case values. The third case has an input variable to indicate that it is the last of the dependent series and the subsequent run will be a new base case.

6.0 DIAGNOSTICS

Input editing for system errors is accomplished by the FORTRAN Namelist feature. Such errors as mispunched header cards, mispunching or misspelling of input variable names, omission of commas and errors in numeric field punching are flagged by Namelist and generally result in problem termination. An additional diagnostic has been included in the program to signal a premature end-of-file in the input stream, i.e. before an &END trailer card has been reached.

The program has been written to provide automatically for such contingencies as undersized process units, and deficiencies in hydrogen or fuel availability by blending off excess feed streams and by indicating the need for purchase. The greatest propensity of the program to fail in the calculation is probably in the jet fuel, distillate and residual fuel oil blending calculations. The problem arises in trying to make specified fuels outside of the ability of the program to do so -- for example, if a hydrogen specification content of 15.0 weight percent were specified for a 650°F endpoint jet fuel blend and the highest blending component hydrogen content were 14.8 weight percent.

The subroutine involved in making the blending calculation is BMAX. Either or both of two messages are issued by BMAX if a blending problem develops:

"A FUEL OIL BLEND CALCULATION HAS FAILED -- CHECK INPUT"

"A ZERO DIVIDE HAS OCCURED IN SUBROUTINE BMAX -- THE RESULTS ARE THEREFORE SUSPECT -- CHECK PROBLEM INPUT"

The input checks under this circumstance would usually consist of redefining a feasible problem, i.e., a refinery configuration capable of making the specified blends.

7.0 CONCLUDING REMARKS

This report has described the Gordian Refinery Simulation Model, a Fortran computing program for predicting the flow streams and material, energy, and economic balances of a typical petroleum refinery, with particular emphasis on production of aviation turbine fuel of varying end point and hydrogen content specifications. Program logic, optional and required input, default values, diagnostics, and sample output are discussed. A brief example is included, illustrating the case feature for parametric or optimization study variations of a base case.

It is felt that the material presented in this report will be sufficient for the needs of many readers. The simplicity and flexibility of the program can be readily assessed, and the limitations should be apparent, particularly with respect to uncertain reliability when dealing with the properties of shale and coal syncrudes. The sample input and output printouts presented here can serve as a guide for interpretation of future reported listings and data. Additional details, however, will be found in Volume II of this report series (NASA CR-135334) covering the mathematics and data bases and Volume III covering the program listing, both documents to be available from the NASA Project Manager. Computer documentation and tapes can be purchased through the Computer Software and Management Information Office (COSMIC), 112 Barrow Hall, University of Georgia, Athens, GA, 30602, under the number LEW-13047.

8.0 REFERENCES

1. Kalfadelis, Charles D.: Evaluation of Methods to Produce Aviation Turbine Fuels from Synthetic Crude Oils - Phase II. AFAPL-TR-75-10-Volume II, 1976.
2. Antoine, A.C.; and Gallagher, J.P.: Jet Fuels from Synthetic Crudes. C.E.P. Technical Manual, Coal Processing Technology, Vol. 3 AICHE New York, 1977, pp. 23-27.
3. Bonner and Moore, Associates: U.S. Motor Gasoline Economics, Vol. 1, Manufacture of Unleaded Gasoline. Amer. Petroleum Inst., Washington, 1967.
4. Technical Data Book - Petroleum Refining. Third ed. Amer. Petroleum Inst., Washington, 1976.
5. Nelson, W.L.: Petroleum Refinery Engineering. Fourth ed. McGraw-Hill Book Co., 1969.
6. Reid, Eugene B.; and Allen, Howard I.: Estimating Pour Points of Petroleum Distillate Blends. Petroleum Refiner, Vol. 30, no. 5, May 1951, pp. 93-95.

LISTS OF EXHIBITS

EXHIBIT 1

COMPUTER PRINTOUT FOR A SAMPLE CASE

On the following pages, a printout of a sample case using the Gordian Refinery Simulation Model is reproduced. On the first page, the optional input data are illustrated. A crude assay data change input is shown between &CDATA and &END, an alkylation unit feed nitrogen content change between &UDATA and &END, and an alkylation unit product octane number change between &UDATA1 and &END. (The printing unit lacks a & symbol and substitutes a \$ on the printout). On the second page, required data between &PDATA and &END are shown. The selected case represents a refinery model with crude feed of 33,000 BPD each of Agha Jari petroleum, Paraho shale, and Kentucky synthoil coal oil. The input variables prescribe the sizes of the process units, catalytic cracker conversion, mid-distillate operation, and medium hydrotreater and hydrocracker severity. These input values are summarized on a page titled, "SUMMARY OF REFINERY UNIT OPERATIONS" near the end of the printout pages. The input IREP=3 specifies a complete printout, including all material balances and economic calculations. The production of jet fuel pools with a specified 600°F end point and 12.8% hydrogen is indicated. This sample case is discussed briefly in Section 2.2 of this report.

1...INPUT CARO IMAGES

SPDATA

ICASE=1,IREP=3,
CV19)=3300.0,CV(11)=3300.0,ALKY=2000.0,BI=1000.0,FCC=3000.0,
CV19)=3300.0,GCHYC=5000.0,MODE=2,HTKERO=1000.0,HVD=50.0,POLY=500.0,
CONV=7.0,VACO=2000.0,COKER=5000.0,VACS=2000.0,VACC=2000.0,
REF=2000.0,REFROM=95.0,FCC=1000.0,COKE=5000.0,DIESEL=500.0,KERO=500.0,
SOKHT=2000.0,COKHT=200.0,CGCHYC=1000.0,SGCHYC=500.0,STRF=0.92,PFPR=3.00,
DP83L=70.15.00,IVESTCC=C.15,CENTKWH=2.5,14.70,12.30,8.00,9.0.0,
PD33L=9.00,10.00,13.00,14.75,13.00,16.00,15.00,14.70,12.30,8.00,9.0.0,
GODES=1000.0,MODES=1000.0,MDHYC=1000.0,EPSP=600.0,HDSP=12.8,
SEND

MATERIAL BALANCE REPORT

| FEED STREAMS | KG/M 3 | (API | WT PCT SULFUR | WT PCT NITROGEN | WT PCT HYDROGEN | KG/SEC STREAM | (LBS/HR) STREAM | KG/SEC SULFUR | (LBS/HR) SULFUR | KG/SEC NITROGEN | (LBS/HR) NITROGEN | KG/SEC HYDROGEN | (LBS/HR) HYDROGEN |
|-----------------|--------|--------|------------------|--------------------|--------------------|------------------|--------------------|------------------|--------------------|--------------------|----------------------|--------------------|----------------------|
| CRUDE OIL MIX | 852.62 | 34.300 | 1.3400 | .13 | 13.03 | 51.72 | 410458. | .693 | 5500.3 | .0672 | 5336.6 | 6.72 | 53361. |
| TOTAL INPUT | | | | | | 51.72 | 410458. | .69 | 5500. | .07 | 534. | 6.72 | 53361. |

PRODUCT STREAMS

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LOSS AND UNACCOUNTED FOR

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| STREAM | KG/SEC | | | | | | |
| STEAM | 3.9 | 31325.0 | 2.8 | 1195.0 | 37.4 | 6.2 | .156 |
| FUEL | 1.4 | 10854.0 | 48.8 | 21000.0 | 227.9 | 37.7 | .949 |
| POWER | | | | .9 | 3.0 | .5 | .012 |
| TOTALS | | | | 78.6 | 268.3 | 44.4 | 1.117 |

CRUDE UNIT(SHALE) MATERIAL BALANCE REPORT

| FEED STREAMS | KG/H 3 (API) | WT PCT SULFUR | WT PCT NITROGEN | WT PCT HYDROGEN | KG/SEC STREAM | KG/SEC SULFUR | KG/SEC NITROGEN | KG/SEC HYDROGEN | KG/SEC NITROGEN | KG/SEC HYDROGEN | KG/SEC NITROGEN | KG/SEC HYDROGEN |
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| SHALE OIL MIX | 937.43 | 19.300 | .7100 | 2.00 | 11.50 | 56.06 | 451297. | .404 | 3204.2 | 1.1373 | 9025.9 | 6.54 |
| TOTAL INPUT | | | | | | 56.06 | 451297. | .40 | 3204. | 1.14 | 9026. | 6.54 |

PRODUCT
STREAMS

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|--------------------------|---------|--------|-------|------|-------|-------|---------|------|--------|-------|--------|------|--------|
| HEAVY NAPHTHA | 821.55 | 43.570 | .9023 | .00 | 12.50 | .75 | 5933. | .007 | 53.5 | .0000 | .1 | .09 | 742. |
| LIGHT KEROSENE | 852.82 | 34.260 | .6587 | 1.01 | 12.20 | 3.88 | 30793. | .026 | 202.8 | .0392 | 311.0 | .47 | 3757. |
| HEAVY KEROSENE | 891.27 | 27.110 | .5920 | 1.90 | 11.50 | 8.65 | 88632. | .060 | 474.4 | .1644 | 1305.0 | .99 | 7895. |
| SHALE GAS OIL | 946.53 | 17.850 | .6038 | 2.00 | 10.90 | 30.62 | 243029. | .184 | 1460.1 | .6115 | 4853.5 | 3.34 | 26490. |
| VACUUM BOTTOMS | 1033.36 | 5.300 | .4000 | 3.06 | 9.40 | 4.56 | 36181. | .018 | 144.7 | .1395 | 1107.1 | .43 | 3401. |
| REDUCED CRUDE | 956.95 | 16.224 | .5748 | 2.13 | 10.71 | 8.36 | 66312. | .348 | 381.1 | .1784 | 1415.7 | .89 | 7099. |
| TOTAL OUTPUT | | | | | | 56.81 | 450899. | .34 | 2717. | 1.13 | 8992. | 6.23 | 49475. |
| LOSS AND UNACCOUNTED FOR | | | | | | .05 | 399. | .06 | 487. | .00 | 34. | .31 | 2424. |

ENERGY CONSUMPTION REPORT

| CRUDE UNIT(SHALE) | KG/SEC | (LBS/HR) | MM JLS/KG | (BTU/LB) | MILLION JOULES/SEC | (BTU/HR) | (89L FOE) (PER HR) | PCT REFINERY INPUT |
|-------------------|--------|----------|-----------|----------|-----------------------|----------|-------------------------|-----------------------|
| STEAM | 3.9 | 31325.8 | 2.8 | 1195.0 | 11.0 | 37.4 | 6.2 | .156 |
| FUEL | 1.4 | 10854.0 | 48.8 | 21000.0 | 66.8 | 227.9 | 37.7 | .949 |
| POWER | | | | | .9 | 3.0 | .5 | .012 |
| TOTALS | | | | | 78.6 | 268.3 | 44.4 | 1.117 |

KEROSENEHYDRO TREATER MATERIAL BALANCE REPORT

| FEED STREAMS | KG/M 3 (API) | | WT PCT | | KG/SEC (LBS/HR) | | KG/SEC (LBS/HR) | | KG/SEC (LBS/HR) | | KG/SEC (LBS/HR) | |
|-----------------|----------------|---------|--------|---------|-----------------|---------|-----------------|--------|-----------------|--------|-----------------|--------|
| | WT PCT | WT PCT | WT PCT | WT PCT | KG/SEC | KG/SEC | KG/SEC | KG/SEC | KG/SEC | KG/SEC | KG/SEC | KG/SEC |
| HYDROGEN | 334.48 | 291.140 | 0.00 | 100.00 | 0.00 | 22.0 | 0.000 | 0.0 | 0.0000 | 0.0 | 0.0 | 22.0 |
| LIGHT KEROSENE | 819.50 | 71.000 | 0.00 | 13.60 | 1.51 | 11955.0 | 0.006 | 47.8 | 0.0001 | 0.5 | 0.20 | 1626.0 |
| TOTAL INPUT | | | 1.51 | 11977.0 | 0.01 | 4.8 | 0.00 | 0.0 | 0.21 | 1648.0 | | |

PRODUCT STREAMS

| | | | | | | | | | | | | | |
|--------------------------|--------|---------|---------|---------|-------|------|---------|-------|-------|--------|-----|------|--------|
| ETHANE AND LTR | 399.62 | 222.250 | 48.2532 | 0.46 | 11.39 | 0.01 | 84.0 | 0.005 | 40.6 | 0.0001 | 0.4 | 0.00 | 10.0 |
| GASOLINE | 734.36 | 61.600 | 0.9300 | 0.01 | 14.88 | 0.03 | 257.0 | 0.000 | 2.4 | 0.000 | 0.0 | 0.00 | 38.0 |
| HYDRO TRT LT KER | 817.13 | 71.500 | 0.0409 | 0.00 | 13.73 | 1.47 | 11682.0 | 0.001 | 4.8 | 0.0000 | 0.0 | 0.20 | 1604.0 |
| TOTAL OUTPUT | | | 1.51 | 12024.0 | 0.01 | 4.8 | 0.00 | 0.0 | 0.21 | 1651.0 | | | |
| LOSS AND UNACCOUNTED FOR | | | -0.01 | -46.0 | 0.00 | 0.0 | 0.00 | 0.0 | -0.00 | -3.0 | | | |

KEROSENEHYDRO TREATER ENERGY CONSUMPTION REPORT

| STREAM | KG/SEC (LBS/HR) | | MM JLS/KG (BTU/LB) | | MILLION (BTU/HR) | | (BBL F0E) (PER HR) | | PCT REFINERY INPUT | |
|----------|-----------------|--------|--------------------|-----------|------------------|------------|----------------------|------------|--------------------|-------|
| | KG/SEC | KG/SEC | MM JLS/KG | MM JLS/KG | JOULES/SEC | JOULES/SEC | (BTU/HR) | (BTU/HR) | INPUT | INPUT |
| STEAM | 0.0 | 295.3 | 2.8 | 1195.0 | 0.1 | 0.4 | 0.1 | 0.001 | | |
| FUEL | 0.0 | 208.9 | 48.8 | 21000.0 | 1.3 | 4.4 | 0.7 | 0.018 | | |
| POWER | 0.0 | 22.0 | 120.2 | 51667.0 | 0.3 | 1.1 | 0.2 | 0.001 | | |
| HYDROGEN | 0.0 | 22.0 | 120.2 | 51667.0 | 0.3 | 1.1 | 0.2 | 0.001 | | |
| TOTALS | | | | | 1.8 | 6.1 | 1.0 | 0.025 | | |

MATERIAL BALANCE REPORT

FLUID COKER

| FEED STREAMS | KG/M 3 (API) | WT PCT | WT PCT | WT PCT | KG/SEC (LBS/HR) | KG/SEC (LBS/HR) | KG/SEC (LBS/HR) | KG/SEC (LBS/HR) | KG/SEC (LBS/HR) | KG/SEC (LBS/HR) | KG/SEC (LBS/HR) | KG/SEC (LBS/HR) | KG/SEC (LBS/HR) |
|----------------|----------------|--------|--------|--------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| | | | | | | | | | | | | | |
| VACUUM BOTTOMS | 1081.69 | -0.740 | 0.9694 | 1.37 | 9.08 | 9.94 | 78858. | 0.96 | 764.4 | 0.1362 | 1080.6 | 0.90 | 7157. |
| TOTAL INPUT | | | | | | 9.94 | 78858. | 0.10 | 764. | 0.14 | 1081. | 0.90 | 7157. |

PRODUCT STREAMS

| ETHANE AND LTR | 399.62 | 222.250 | 6.9872 | 9.88 | 18.47 | 0.45 | 3610. | 0.32 | 252.3 | 0.0449 | 356.6 | 0.08 | 667. |
|----------------|---------|---------|--------|------|-------|------|--------|------|-------|--------|-------|------|-------|
| PROPANE | 507.21 | 147.203 | 0.2672 | 0.38 | 18.06 | 0.11 | 858. | 0.00 | 2.3 | 0.0034 | 3.2 | 0.02 | 155. |
| PROPYLENE | 521.50 | 139.573 | 0.7045 | 0.43 | 14.18 | 0.09 | 753. | 0.00 | 2.3 | 0.0054 | 3.2 | 0.01 | 107. |
| ISO BUTANE | 562.56 | 119.793 | 0.2202 | 0.59 | 17.57 | 0.07 | 545. | 0.00 | 2.3 | 0.0034 | 3.2 | 0.01 | 93. |
| N-BUTANE | 583.87 | 110.629 | 0.0938 | 2.11 | 16.62 | 0.02 | 153. | 0.00 | 2.3 | 0.0034 | 3.2 | 0.00 | 25. |
| BTYLENE | 630.42 | 102.394 | 0.2874 | 0.41 | 14.19 | 0.10 | 798. | 0.00 | 2.3 | 0.0034 | 3.2 | 0.01 | 113. |
| LIGHT GASOLINE | 742.06 | 59.260 | 0.1820 | 0.26 | 14.65 | 0.69 | 5460. | 0.01 | 9.9 | 0.0018 | 14.0 | 0.10 | 800. |
| HEAVY GASOLINE | 800.30 | 44.260 | 0.179 | 0.59 | 13.44 | 0.78 | 6219. | 0.03 | 26.0 | 0.0045 | 36.7 | 0.11 | 836. |
| COKER GAS OIL | 931.50 | 20.263 | 0.6103 | 0.80 | 11.64 | 4.13 | 32818. | 0.25 | 200.3 | 0.0357 | 283.1 | 0.48 | 3820. |
| COKE | 1075.01 | 0.000 | 1.2133 | 1.72 | 2.00 | 2.75 | 21799. | 0.33 | 264.5 | 0.0471 | 373.9 | 0.05 | 436. |
| TOTAL OUTPUT | | | | | | 9.20 | 73014. | 0.10 | 764. | 0.14 | 1081. | 0.89 | 7053. |

LOSS AND UNACCOUNTED FOR

| | | | | | | | |
|--|------|-------|------|----|----|------|------|
| | 0.74 | 5844. | 0.00 | 0. | 0. | 0.01 | 104. |
|--|------|-------|------|----|----|------|------|

FLUID COKER

ENERGY CONSUMPTION REPORT

| STREAM | KG/SEC | (LBS/HR) | MM JLS/KG (BTU/LB) | MILLION (BTU/HR) | (BBL FEE) (PER HR) | PCT REFINERY INPUT |
|--------|--------|----------|--------------------|------------------|--------------------|--------------------|
| STEAM | -0.5 | -4219.0 | 2.8 | 1195.0 | -0.8 | -0.021 |
| FUEL | 0.2 | 1980.7 | 48.8 | 21000.0 | 6.9 | .173 |
| POWER | | | | 1.2 | 4.3 | .018 |
| TOTALS | | | | 12.0 | 6.7 | .170 |

CATALYTIC CRACKER MATERIAL BALANCE REPORT

| FEED STREAMS | KG/M 3 (API | WT PCT SULFUR | WT PCT NITROGEN | WT PCT HYDROGEN | KG/SEC STREAM | KG/SEC (LBS/HR) STREAM | KG/SEC SULFUR | KG/SEC (LBS/HR) SULFUR | KG/SEC NITROGEN | KG/SEC (LBS/HR) NITROGEN | KG/SEC HYDROGEN | KG/SEC (LBS/HR) HYDROGEN |
|-----------------|--------------|------------------|--------------------|--------------------|------------------|---------------------------|------------------|---------------------------|--------------------|-----------------------------|--------------------|-----------------------------|
| VACUUM GAS OIL | 914.98 | 23.600 | .11 | 12.20 | 7.92 | 59723. | .133 | 1057.1 | .0079 | 62.7 | .92 | 7286. |
| COKE GAS OIL | 931.50 | 23.260 | .86 | 11.64 | 3.45 | 27348. | .021 | 166.3 | .0297 | 235.9 | .40 | 3184. |
| TOTAL INPUT | | | | | 10.97 | 37071. | .15 | 1224. | .04 | 299. | 1.32 | 10470. |

PRODUCT STREAMS

| | | | | | | | | | | | | | |
|-----------------|--------|---------|---------|------|-------|-------|--------|------|-------|-------|------|------|--------|
| ETHANE AND LTR | 399.62 | 222.250 | 15.0134 | 3.66 | 18.07 | .31 | 2445. | .046 | 367.2 | .0113 | 89.6 | .06 | 442. |
| PROPANE | 507.21 | 147.208 | 1.0100 | .23 | 17.95 | .15 | 1212. | .002 | 12.2 | .0304 | 3.0 | .03 | 218. |
| PROPYLENE | 521.50 | 139.573 | .2460 | .03 | 14.24 | .63 | 4976. | .002 | 12.2 | .0004 | 3.0 | .09 | 709. |
| ISO BUTANE | 562.56 | 119.788 | .6214 | .15 | 17.11 | .25 | 1970. | .002 | 12.2 | .0004 | 3.0 | .04 | 337. |
| N-BUTANE | 583.84 | 110.629 | 1.9408 | .45 | 16.85 | .08 | 655. | .002 | 12.2 | .0004 | 3.0 | .01 | 112. |
| BUTYLENE | 604.42 | 102.384 | .4468 | .11 | 14.21 | .35 | 2740. | .002 | 12.2 | .0004 | 3.0 | .05 | 389. |
| TOTAL GASOLINE | 791.16 | 77.179 | .1158 | .03 | 13.39 | 5.33 | 42288. | .006 | 49.0 | .0015 | 11.9 | .71 | 5663. |
| LIGHT CYCLE OIL | 897.83 | 25.950 | 1.5570 | .38 | 11.49 | 2.56 | 20309. | .040 | 318.2 | .0098 | 77.6 | .29 | 2333. |
| BITUMENS | 114.76 | -8.112 | 2.3316 | .57 | 8.15 | 1.26 | 9974. | .029 | 232.6 | .0071 | 56.7 | .10 | 813. |
| TOTAL OUTPUT | | | | | | 10.91 | 86578. | .13 | 1028. | .03 | 251. | 1.39 | 11015. |

LOSS AND UNACCOUNTED FOR

-545.

CATALYTIC CRACKER ENERGY CONSUMPTION REPORT

| STREAM | KG/SEC | (LBS/HR) | MM BLS/KG | (BTU/LB) | MILLION JOULES/SEC | (BTU/HR) | (BBL FOE) (PER HR) | PCT REFINERY INPUT |
|--------|--------|----------|-----------|----------|-----------------------|----------|-------------------------|-----------------------|
| STEAM | -0.7 | -5801.9 | 2.8 | 1195.0 | -2.0 | -6.9 | -1.1 | -.029 |
| FUEL | .2 | 1946.7 | 48.8 | 21000.0 | 12.0 | 40.9 | 6.8 | .170 |
| POWER | | | | | .3 | 1.1 | .2 | .005 |
| TOTALS | | | | | 10.3 | 35.1 | 5.8 | .146 |

THERMAL CRACKER MATERIAL BALANCE REPORT

| FEED STREAMS | KG/M 3 (API) | WT PCT SULFUR | WT PCT NITROGEN | WT PCT HYDROGEN | KG/SEC (LBS/HR) STREAM | KG/SEC (LBS/HR) SULFUR | KG/SEC (LBS/HR) NITROGEN | KG/SEC (LBS/HR) HYDROGEN | KG/SEC (LBS/HR) NITROGEN | KG/SEC (LBS/HR) HYDROGEN | | | |
|-----------------|-------------------|------------------|--------------------|--------------------|---------------------------|---------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-------|-----|-------|
| VACUUM GAS OIL | 914.98 | 23.300 | 1.7700 | .11 | 12.20 | 2.51 | 19908. | .044 | 352.4 | .0026 | 20.9 | .31 | 2429. |
| TOTAL INPUT | | | | 2.51 | 19908. | .04 | 352. | .00 | 21. | .31 | 2429. | | |

PRODUCT STREAMS

| | | | | | | | | | | | | | |
|--------------------------|--------|---------|---------|------|--------|------|--------|------|-------|--------|-------|-----|-------|
| ETHANE AND LTR | 399.62 | 222.253 | 14.6201 | .87 | 18.78 | .11 | 844. | .016 | 123.3 | .0009 | 7.3 | .02 | 158. |
| PROPANE | 507.21 | 147.208 | .6140 | .04 | 18.06 | .07 | 574. | .000 | 3.5 | .0000 | .2 | .01 | 104. |
| PROPYLENE | 521.50 | 139.573 | 1.6345 | .10 | 14.04 | .03 | 216. | .000 | 3.5 | .0000 | .2 | .00 | 30. |
| ISO BUTAE | 562.56 | 119.788 | 2.3993 | .02 | 16.83 | .02 | 147. | .000 | 3.5 | 0.0000 | 0.0 | .00 | 25. |
| N-BUTANE | 583.84 | 110.629 | .8159 | .05 | 17.09 | .05 | 432. | .000 | 3.5 | .0000 | .2 | .01 | 74. |
| BUTYLENE | 604.42 | 102.384 | .8932 | .05 | 14.15 | .05 | 395. | .000 | 3.5 | .0000 | .2 | .01 | 56. |
| TOTAL GASOLINE | 787.54 | 48.600 | .2587 | .02 | 13.39 | .69 | 5449. | .002 | 14.1 | .0001 | .8 | .09 | 730. |
| HEAVY FUEL | 914.98 | 23.000 | 1.7732 | .11 | 12.81 | 1.40 | 11128. | .025 | 197.3 | .0015 | 11.7 | .18 | 1425. |
| TOTAL OUTPUT | | | | 2.42 | 19133. | .04 | 352. | .30 | 21. | .33 | 2602. | | |
| LOSS AND UNACCOUNTED FOR | | | | .09 | 724. | .00 | 0. | .00 | 0. | .02 | -173. | | |

THERMAL CRACKER ENERGY CONSUMPTION REPORT

| STREAM | KG/SEC | (LBS/HR) | MM BTL/KG | (BTU/LB) | MILLION | (MILLION) | (BBL FOS) | PCT REFINERY |
|--------|--------|----------|-----------|----------|------------|-----------|------------|--------------|
| | | | | | JOULES/SEC | (BTU/HR) | (PER HR) | INPUT |
| STEAM | .3 | 5977.6 | 2.8 | 1195.0 | 2.1 | 7.1 | 1.2 | .030 |
| FUEL | .2 | 1969.3 | 48.8 | 21000.0 | 12.1 | 41.4 | 6.8 | .172 |
| POWER | | | | | .1 | .4 | .1 | .002 |
| TOTALS | | | | | 14.3 | 48.9 | 8.1 | .204 |

GAS OIL HYDRO CRACKER MATERIAL BALANCE REPORT

| FEED STREAMS | KG/M 3 (API) | WT PCT SULFUR | WT PCT NITROGEN | WT PCT HYDROGEN | KG/SEC STREAM | KG/SEC (LBS/HR) STREAM | KG/SEC SULFUR | KG/SEC (LBS/HR) SULFUR | KG/SEC NITROGEN | KG/SEC (LBS/HR) NITROGEN | KG/SEC (LBS/HR) HYDROGEN | KG/SEC (LBS/HR) HYDROGEN |
|-----------------|----------------|------------------|--------------------|--------------------|------------------|---------------------------|------------------|---------------------------|--------------------|-----------------------------|-----------------------------|-----------------------------|
| HYDROGEN | 334.48 | 291.143 | 0.0000 | 0.00 | 100.00 | 667. | 0.000 | 0.0 | 0.0000 | 0.0 | 0.0 | 667. |
| VACUUM GAS OIL | 914.98 | 23.003 | 1.7700 | 1.25 | 12.20 | 9934. | 0.022 | 176.2 | 0.013 | 10.5 | 10.5 | 1214. |
| COKE GAS OIL | 931.50 | 20.260 | 0.6193 | 0.86 | 11.64 | 4558. | 0.064 | 27.8 | 0.050 | 39.3 | 39.3 | 531. |
| TOTAL INPUT | | | | 1.91 | 15178. | | 0.03 | 204. | 0.01 | 50. | 50. | 2412. |

PRODUCT STREAMS

| | | | | | | | | | | | | |
|------------------|--------|---------|---------|-------|--------|-------|-------|-------|--------|------|------|-------|
| ETHANE AND LTR | 399.62 | 222.250 | 63.3585 | 15.46 | 4.71 | 319. | 0.025 | 202.0 | 0.062 | 49.3 | 49.3 | 15. |
| PROPANE | 507.2 | 147.208 | 0.0300 | 0.00 | 18.18 | 194. | 0.000 | 0.0 | 0.0000 | 0.0 | 0.0 | 35. |
| ISO BUTANE | 562.56 | 119.798 | 0.0000 | 0.00 | 17.24 | 88. | 0.000 | 0.0 | 0.0000 | 0.0 | 0.0 | 15. |
| N-BUTANE | 583.84 | 113.629 | 0.0000 | 0.00 | 17.24 | 176. | 0.000 | 0.0 | 0.0000 | 0.0 | 0.0 | 30. |
| LIGHT GASOLINE | 707.71 | 58.248 | 0.0834 | 0.02 | 16.30 | 489. | 0.000 | 0.4 | 0.0000 | 0.1 | 0.1 | 80. |
| HEAVY GASOLINE | 749.67 | 57.069 | 0.130 | 0.00 | 15.59 | 3145. | 0.000 | 0.4 | 0.0000 | 0.1 | 0.1 | 490. |
| HYDRO TRI LT KER | 814.12 | 42.141 | 0.116 | 0.00 | 13.82 | 5264. | 0.000 | 0.6 | 0.0000 | 0.1 | 0.1 | 728. |
| DESUL HYKER | 853.44 | 34.140 | 0.111 | 0.00 | 13.66 | 5519. | 0.000 | 0.6 | 0.0000 | 0.1 | 0.1 | 754. |
| TOTAL OUTPUT | | | | 1.91 | 15195. | | 0.03 | 204. | 0.01 | 50. | 50. | 2147. |

LOSS AND UNACCOUNTED FOR

GAS OIL HYDRO CRACKER ENERGY CONSUMPTION REPORT

| STREAM | KG/SEC | (LBS/HR) | MM BLS/KG | (BTU/LB) | MILLION JOULES/SEC | (BTU/HR) | (BBL FCE) (PER HR) | PCT REFINERY INPUT |
|----------|--------|----------|-----------|----------|-----------------------|----------|-------------------------|-----------------------|
| STEAM | 0 | 114.0 | 2.8 | 1195.0 | 0 | 0 | 0 | 0.001 |
| FUEL | 0 | 172.6 | 48.8 | 21000.0 | 1.1 | 3.6 | 0.6 | 0.015 |
| POWER | | | | | 0.4 | 1.5 | 0.2 | 0.006 |
| HYDROGEN | 0.1 | 666.6 | 120.2 | 51667.0 | 10.1 | 34.4 | 5.7 | 0.143 |
| TOTALS | | | | | 11.6 | 39.7 | 6.6 | 0.165 |

GAS OIL DESULFURIZER MATERIAL BALANCE REPORT

| FEED STREAMS | KG/M 3 (API) | WT PCT SULFUR | WT PCT NITROGEN | WT PCT HYDROGEN | KG/SEC (LBS/HR) STREAM | KG/SEC (LBS/HR) SULFUR | KG/SEC (LBS/HR) NITROGEN | KG/SEC (LBS/HR) HYDROGEN | KG/SEC (LBS/HR) HYDROGEN |
|-----------------|----------------|------------------|--------------------|--------------------|---------------------------|---------------------------|-----------------------------|-----------------------------|-----------------------------|
| HYDROGEN | 334.48 | 231.140 | 0.00 | 100.00 | 29. | 0.000 | 0.0 | 0.0 | 29. |
| VACUUM GAS OIL | 914.98 | 23.000 | .11 | 12.20 | 1991. | .004 | 35.2 | 2.1 | 243. |
| COKE GAS OIL | 931.50 | 20.260 | .86 | 11.64 | 912. | .001 | 5.6 | 7.9 | 106. |
| TOTAL INPUT | | | .37 | 2932. | | .01 | 41. | 10. | 378. |

PRODUCT STREAMS

| | | | | | | | | | | | | | |
|----------------|--------|---------|---------|-------|-------|-----|-------|------|------|-------|-----|-----|------|
| ETHANE AND LTR | 399.62 | 222.250 | 44.4256 | 10.84 | 9.94 | .01 | 78. | .004 | 34.7 | .0011 | 8.5 | .00 | 8. |
| DISTILLATE | 829.12 | 39.000 | 1.3952 | .08 | 13.53 | .02 | 126. | .000 | 1.8 | .0000 | .1 | .00 | 17. |
| DISTILLATE | 82.65 | 36.260 | .4819 | .68 | 13.12 | .01 | 58. | .000 | .3 | .0000 | .4 | .00 | 8. |
| DESUL GAS OIL | 903.29 | 25.000 | .1928 | .01 | 12.63 | .23 | 1828. | .000 | 3.5 | .0000 | .2 | .03 | 231. |
| DESUL GAS OIL | 919.38 | 22.260 | .6655 | .09 | 12.20 | .11 | 837. | .000 | .6 | .0001 | .8 | .01 | 102. |
| TOTAL OUTPUT | | | | .37 | 2927. | .01 | 41. | .00 | 41. | .00 | 10. | .05 | 365. |

LOSS AND UNACCOUNTED FOR

| | | | | | | | | | | | | | |
|--|-----|----|-----|----|-----|-----|----|-----|----|-----|----|-----|-----|
| | .00 | 5. | .00 | 0. | .00 | .00 | 0. | .00 | 0. | .00 | 0. | .00 | 13. |
|--|-----|----|-----|----|-----|-----|----|-----|----|-----|----|-----|-----|

GAS OIL DESULFURIZER ENERGY CONSUMPTION REPORT

| STREAM | KG/SEC (LBS/HR) | MM BLS/KG (BTU/LB) | MILLION JOULES/SEC (BTU/HR) | (BBL FEE) (PER HR) | PCT REFINERY INPUT |
|----------|--------------------|-----------------------|-----------------------------------|-------------------------|-----------------------|
| STEAM | .0 | 63.9 | 2.8 | 1195.0 | .0 |
| FUEL | .0 | 38.4 | 48.8 | 21000.0 | .1 |
| POWER | .0 | | .0 | .0 | .003 |
| HYDROGEN | .0 | 29.4 | 120.2 | 51667.0 | .000 |
| TOTALS | | | .7 | 2.4 | .010 |

DISTILLATE DESULFURIZER MATERIAL BALANCE REPORT

| FEED | | KG/M 3 | (API | WT PCT | WT PCT | WT PCT | KG/SEC | (LBS/HR) | KG/SEC | (LBS/HR) | KG/SEC | (LBS/HR) | KG/SEC | (LBS/HR) | KG/SEC | (LBS/HR) |
|--------------------------|--------|---------|---------|--------|----------|----------|--------|----------|--------|----------|----------|----------|----------|----------|--------|----------|
| STREAMS | | | | SULFUR | NITROGEN | HYDROGEN | STREAM | STREAM | SULFUR | SULFUR | NITROGEN | NITROGEN | HYDROGEN | HYDROGEN | | |
| HYDROGEN | 334.48 | 291.140 | 0.5000 | 0.00 | 100.00 | .01 | 80. | 0.003 | 0.0 | 0.0090 | 0.0 | 0.01 | 80. | | | |
| HEAVY KEROSENE | 854.16 | 34.000 | .9500 | .01 | 13.10 | 1.14 | 9057. | .011 | 86.0 | .0031 | .9 | .15 | 1186. | | | |
| LIGHT CYCLE OIL | 897.83 | 25.950 | 1.5670 | .38 | 11.49 | .45 | 3578. | .007 | 56.1 | .0017 | 13.7 | .05 | 411. | | | |
| TOTAL INPUT | | | | 1.60 | 12715. | .02 | 142. | .30 | 15. | .21 | 1678. | | | | | |
| PRODUCT | | | | | | | | | | | | | | | | |
| STREAMS | | | | | | | | | | | | | | | | |
| ETHANE AND LTR | 399.62 | 222.250 | 71.7831 | 7.37 | 4.63 | .02 | 186. | .017 | 133.6 | .0017 | 13.7 | .00 | 9. | | | |
| GASOLINE | 771.52 | 51.729 | .5739 | .01 | 13.83 | .03 | 246. | .000 | 1.4 | .0000 | .1 | .00 | 34. | | | |
| DESUL LTCYCLE | 886.57 | 27.950 | .0820 | .02 | 11.96 | .44 | 3463. | .000 | 2.8 | .0001 | .7 | .05 | 414. | | | |
| DESUL HYKER | 843.97 | 36.000 | .0191 | .01 | 13.49 | 1.10 | 8770. | .001 | 4.3 | .0000 | .0 | .15 | 1183. | | | |
| TOTAL OUTPUT | | | | 1.60 | 12666. | .02 | 142. | .00 | 15. | .21 | 1640. | | | | | |
| LOSS AND UNACCOUNTED FOR | | | | | | | | | | | | | | | | |
| | | | | .01 | 49. | .00 | 0. | .00 | 0. | .00 | 0. | .00 | 37. | | | |

DISTILLATE DESULFURIZER ENERGY CONSUMPTION REPORT

| STREAM | KG/SEC | (LBS/HR) | MM JLS/KG | (BTU/LB) | MILLION JOULES/SEC | (BTU/HR) | (BBL FOE) (PER HR) | PCT REFINERY INPUT |
|----------|--------|----------|-----------|----------|-----------------------|----------|-------------------------|-----------------------|
| STEAM | .0 | 214.6 | 2.8 | 1195.0 | .1 | .3 | .0 | .001 |
| FUEL | .0 | 151.8 | 48.8 | 21000.0 | .9 | 3.2 | .5 | .013 |
| POWER | | | | | .0 | .2 | .0 | .001 |
| HYDROGEN | .0 | 35.1 | 120.2 | 51667.0 | .5 | 1.8 | .3 | .008 |
| TOTALS | | | | | 1.6 | 5.4 | .9 | .023 |

DISTILLATE HYDROCRACKER MATERIAL BALANCE REPORT

| FEED STREAMS | KG/M 3 (API) | WT PCT SULFUR | WT PCT NITROGEN | WT PCT HYDROGEN | KG/SEC STREAM | KG/SEC STREAM | KG/SEC SULFUR | KG/SEC SULFUR | KG/SEC NITROGEN | KG/SEC NITROGEN | KG/SEC HYDROGEN | KG/SEC HYDROGEN |
|-----------------|----------------|------------------|--------------------|--------------------|------------------|------------------|------------------|------------------|--------------------|--------------------|--------------------|--------------------|
| HYDROGEN | 334.48 | 291.143 | 0.0030 | 0.00 | 100.00 | .09 | 621. | 0.000 | 0.0 | 0.0000 | 0.0 | .08 |
| HEAVY KEROSENE | 854.18 | 34.030 | .61 | 13.10 | 1.14 | 9057. | .011 | 86.0 | .0001 | .9 | .15 | 1186. |
| LIGHT CYCLE OIL | 897.83 | 25.950 | .38 | 11.49 | .43 | 3578. | .007 | 56.1 | .0017 | 13.7 | .05 | 411. |
| TOTAL INPUT | | | | | 1.07 | 13256. | .02 | 142. | .00 | 15. | .28 | 2218. |

PRODUCT
STREAMS

| | | | | | | | | | | | | |
|--------------------------|--------|---------|---------|------|-------|--------|-------|-------|-------|--------|------|-------|
| ETHANE AND LTR | 399.62 | 222.250 | 38.9696 | 4.05 | 12.67 | .05 | 361. | .018 | 140.7 | .0018 | 14.4 | .01 |
| PROPANE | 597.21 | 147.208 | 0.0000 | 0.00 | 18.18 | .09 | 752. | 0.000 | 0.0 | 0.0000 | 0.0 | .02 |
| ISO BUTANE | 562.56 | 119.738 | 0.0000 | 0.00 | 17.24 | .16 | 1296. | 0.000 | 0.0 | 0.0000 | 0.0 | .03 |
| N-BUTANE | 537.84 | 110.629 | 0.0000 | 0.00 | 17.24 | .08 | 672. | 0.000 | 0.0 | 0.0000 | 0.0 | .01 |
| PENTANES | 629.40 | 93.103 | .6392 | .61 | 16.66 | .23 | 1813. | .000 | .7 | .0000 | .1 | .04 |
| HEAVY GASOLINE | 751.01 | 56.731 | .0095 | .00 | 15.52 | 1.05 | 8351. | .000 | .7 | .0000 | .1 | .16 |
| TOTAL OUTPUT | | | | | 1.67 | 13233. | .02 | 142. | .00 | 15. | .27 | 2118. |
| LOSS AND UNACCOUNTED FOR | | | | | .00 | 22. | .00 | 0. | .00 | 0. | .01 | 100. |

DISTILLATE HYDROCRACKER ENERGY CONSUMPTION REPORT

| STREAM | KG/SEC | (LBS/HR) | MM BLS/KG (BTU/LB) | MILLION JOULES/SEC (BTU/HR) | (BBL FOS) (PER HR) | PCT REFINERY INPUT |
|----------|--------|----------|--------------------|--------------------------------|-------------------------|-----------------------|
| FUEL | .1 | 504.2 | 48.8 | 21000.0 | 3.1 | 10.6 |
| POWER | | | | | .6 | 2.0 |
| HYDROGEN | .1 | 620.6 | 120.2 | 51667.0 | 9.4 | 32.1 |
| TOTALS | | | | 13.1 | 44.7 | .186 |

SHALE KERO HYDROTREATER MATERIAL BALANCE REPORT

| FEED STREAMS | KG/H 3 (API) | WT PCT SULFUR | WT PCT NITROGEN | WT PCT HYDROGEN | KG/SEC (LBS/HR) STREAM | KG/SEC (LBS/HR) SULFUR | KG/SEC (LBS/HR) NITROGEN | KG/SEC (LBS/HR) HYDROGEN | KG/SEC (LBS/HR) SULFUR | KG/SEC (LBS/HR) NITROGEN | KG/SEC (LBS/HR) HYDROGEN |
|--------------------------|----------------|------------------|--------------------|--------------------|---------------------------|---------------------------|-----------------------------|-----------------------------|---------------------------|-----------------------------|-----------------------------|
| HYDROGEN | 334.48 | 291.1-0 | 0.0000 | 100.00 | .28 | 2245. | 0.000 | 0.0 | 0.0000 | 0.0 | 0.0 |
| LIGHT KEROSENE | 852.82 | 34.260 | 1.01 | 12.20 | 1.00 | 7941. | .007 | 52.3 | .0101 | 60.2 | .12 |
| HEAVY KEROSENE | 891.27 | 27.110 | .6910 | 11.50 | 2.23 | 17705. | .015 | 122.3 | .0424 | 336.6 | .26 |
| TOTAL INPUT | | | | | 3.51 | 27891. | .02 | 175. | .05 | 417. | .66 |
| PRODUCT STREAMS | | | | | | | | | | | |
| ETHANE AND LTR | 399.62 | 222.250 | 15.9644 | 38.10 | 10.21 | 1083. | .022 | 172.9 | .0520 | 412.6 | .01 |
| HYDRO TRI LT KER | 804.30 | 44.260 | .0365 | .01 | 14.13 | 8089. | .000 | .5 | .0001 | .8 | .14 |
| HYDRO TRI HY KER | 838.41 | 37.110 | .0068 | .02 | 13.70 | 17988. | .000 | 1.2 | .0004 | 3.4 | .31 |
| TOTAL OUTPUT | | | | | 3.42 | 27159. | .02 | 175. | .05 | 417. | .47 |
| LOSS AND UNACCOUNTED FOR | | | | | .09 | 732. | .00 | 0. | .00 | 0. | .19 |

SHALE KERO HYDROTREATER ENERGY CONSUMPTION REPORT

| STREAM | KG/SEC (LBS/HR) | MM BLS/KG (BTU/LB) | MILLION JOULES/SEC (BTU/HR) | (BBL FEE) (PER HR) | PCT REFINERY INPUT |
|----------|-----------------|--------------------|--------------------------------|----------------------|-----------------------|
| STEAM | .8 | 6328.5 | 2.8 | 1195.0 | 1.3 |
| FUEL | .1 | 720.2 | 48.8 | 2100.0 | 2.5 |
| POWER | | | | | .7 |
| HYDROGEN | .3 | 2244.3 | 120.2 | 51667.0 | 19.2 |
| TOTALS | | | 41.9 | 142.9 | 23.6 |

COAL KERO HYDROTREATER MATERIAL BALANCE REPORT

| FEED STREAMS | KG/H 3 (API) | WT PCT SULFUR | WT PCT NITROGEN | WT PCT HYDROGEN | KG/SEC (LBS/HR) STREAM | KG/SEC (LBS/HR) SULFUR | KG/SEC (LBS/HR) NITROGEN | KG/SEC (LBS/HR) HYDROGEN | KG/SEC (LBS/HR) NITROGEN | KG/SEC (LBS/HR) HYDROGEN | KG/SEC (LBS/HR) NITROGEN | KG/SEC (LBS/HR) HYDROGEN |
|--------------------------|----------------|------------------|--------------------|--------------------|---------------------------|---------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|
| HYDROGEN | 334.48 | 291.140 | 0.000 | 100.00 | .28 | 0.000 | 0.0 | 0.0000 | 0.0 | 0.0 | 0.0 | 2206. |
| LIGHT KEROSENE | 923.35 | 21.600 | .0920 | 10.80 | 1.32 | .001 | 9.6 | .0038 | 30.4 | .14 | 1132. | 1132. |
| HEAVY KEROSENE | 959.05 | 15.900 | .1400 | 10.40 | 2.15 | .003 | 23.9 | .0069 | 54.7 | .22 | 1778. | 1778. |
| TOTAL INPUT | | | | | 3.75 | .00 | 34. | .01 | 85. | .64 | 5115. | |
| PRODUCT STREAMS | | | | | | | | | | | | |
| ETHANE AND LTR | 399.62 | 222.250 | 3.0692 | 19.81 | .14 | .004 | 33.2 | .0106 | 84.3 | .03 | 215. | 215. |
| HYDRO TRI LT KER | 856.23 | 33.600 | .0099 | 12.62 | 1.32 | .000 | .1 | .0000 | .3 | .17 | 1325. | 1325. |
| HYDRO TRI HY KER | 886.85 | 27.900 | .001- | 12.27 | 2.15 | .000 | .2 | .0001 | .5 | .26 | 2096. | 2096. |
| TOTAL OUTPUT | | | | | 3.61 | .00 | 34. | .01 | 85. | .46 | 3635. | 3635. |
| LOSS AND UNACCOUNTED FOR | | | | | .14 | .00 | 0. | 0.00 | 0. | .19 | 1481. | 1481. |

COAL KERO HYDROTREATER ENERGY CONSUMPTION REPORT

| STREAM | KG/SEC (LBS/HR) | MM BLS/KG (BTU/LB) | MILLION JOULES/SEC (BTU/HR) | (MILLION) (BTU/HR) | (BBL F0E) (PER HR) | PCT REFINERY INPUT |
|----------|--------------------|-----------------------|-----------------------------------|-----------------------|-------------------------|-----------------------|
| STEAM | .8 | 6328.5 | 2.2 | 7.6 | 1.3 | .031 |
| FUEL | .1 | 720.2 | 4.4 | 15.1 | 2.5 | .063 |
| POWER | | 48.8 | 1.2 | 4.3 | .7 | .018 |
| HYDROGEN | .3 | 2205.3 | 33.4 | 113.9 | 18.8 | .474 |
| TOTALS | | | 41.3 | 140.9 | 23.3 | .586 |

SHALE OIL HYDRO CRACKER MATERIAL BALANCE REPORT

| FEED STREAMS | KG/M 3 (API) | WT PCT SULFUR | WT PCT NITROGEN | WT PCT HYDROGEN | KG/SEC STREAM | KG/SEC (LBS/HR) STREAM | KG/SEC SULFUR | KG/SEC (LBS/HR) SULFUR | KG/SEC NITROGEN | KG/SEC (LBS/HR) NITROGEN | KG/SEC HYDROGEN | KG/SEC (LBS/HR) HYDROGEN |
|-----------------|----------------|------------------|--------------------|--------------------|------------------|---------------------------|------------------|---------------------------|--------------------|-----------------------------|--------------------|-----------------------------|
| HYDROGEN | 334.48 | 291.140 | 0.0000 | 0.00 | .22 | 1757. | 0.000 | 0.0 | 0.0000 | 0.0 | .22 | 1757. |
| SHALE GAS OIL | 946.53 | 17.850 | .6008 | 2.00 | 8.70 | 69042. | .052 | 414.8 | .1737 | 1378.8 | .95 | 7526. |
| TOTAL INPUT | | | | | 8.92 | 70799. | .05 | 415. | .17 | 1379. | 1.17 | 9282. |

PRODUCT
STRENGTHS

| ETHANE AND LTR | 13.5119 | 4+.91 | 9.24 | .38 | 3909. | .051 | 406.5 | .1703 | 1351.3 | .04 | 278. |
|------------------|---------|-------|-------|------|--------|------|-------|-------|--------|------|-------|
| PROPANE | .2803 | .93 | 17.96 | .02 | 148. | .03C | .4 | .0002 | 1.4 | .00 | 27. |
| ISO BUTAE | .C326 | .11 | 17.22 | .16 | 1272. | .000 | .4 | .0002 | 1.4 | .03 | 219. |
| N-BUTANE | .0895 | .29 | 17.18 | .06 | 468. | .000 | .4 | .0002 | 1.4 | .01 | 80. |
| LIGHT GASOLINE | .C055 | .02 | 14.49 | 1.91 | 15133. | .000 | .8 | .0003 | 2.8 | .28 | 2194. |
| HEAVY GASOLINE | .C043 | .02 | 13.98 | 1.25 | 9946. | .000 | .8 | .0033 | 2.8 | .18 | 1390. |
| HYDRO TRT LT KER | .C101 | .03 | 13.92 | 1.56 | 1236. | .000 | 1.2 | .0005 | 4.1 | .22 | 1721. |
| HYDRO TRT HY KER | .C132 | .06 | 13.84 | .86 | 6820. | .000 | 1.2 | .0005 | 4.1 | .12 | 944. |
| WT SHALEGAS OIL | .C123 | .04 | 12.55 | 2.93 | 23636. | .000 | 2.9 | .0012 | 9.7 | .37 | 2975. |
| TOTAL OUTPUT | | | | 9.18 | 72859. | .05 | 415. | .17 | 1379. | 1.24 | 9827. |

SHALE OIL HYDRO CRACKER "..." ENERGY CONSUMPTION REPORT

| STREAM | KG/SEC | (LBS/HR) | MM BLS/KG | (BTU/LB) | MILLION JOULES/SEC | (BTU/HR) | (88L FOE) (PER HR) | PCT REFINERY INPUT |
|----------|--------|----------|-----------|----------|-----------------------|----------|-------------------------|-----------------------|
| STEAM | 2.0 | 1582.0 | 2.8 | 1195.0 | 5.5 | 18.9 | 3.1 | .079 |
| FUEL | .2 | 2601.6 | 78.8 | 21000.0 | 11.1 | 37.8 | 6.3 | .157 |
| POWER | | | | | 3.1 | 10.7 | 1.8 | .044 |
| HYDROGEN | .2 | 1756.4 | 120.2 | 51667.0 | 26.6 | 90.7 | 15.0 | .378 |
| TOTALS | | | | | 46.3 | 158.1 | 26.1 | .658 |

COAL OILHYDRO CRACKER MATERIAL BALANCE REPORT

| FEED STREAMS | KG/M 3 (API) | WT PCT | | KG/SEC (LBS/HR) | | KG/SEC (LBS/HR) | | KG/SEC (LBS/HR) | | KG/SEC (LBS/HR) | | |
|-----------------|----------------|---------|----------|-------------------|---------|-------------------|--------|-------------------|--------|-------------------|----------|----------|
| | | SULFUR | NITROGEN | HYDROGEN | WT PCT | KG/SEC (LBS/HR) | STREAM | SULFUR | SULFUR | NITROGEN | NITROGEN | HYDROGEN |
| HYDROGEN | 334.48 | 291.143 | 0.0000 | 0.39 | 3061. | 0.0 | 0.000 | 0.0 | 0.39 | 3061. | | |
| COAL GASOIL | 1653.29 | 9.430 | 10.10 | 16.07 | 127514. | 0.019 | 153.0 | 599.3 | 1.62 | 12879. | | |
| TOTAL INPUT | | | | 16.45 | 130574. | .02 | 153. | .08 | 599. | 2.01 | 15940. | |

PRODUCT
STREAMS

| ETHANE AND LTR | 399.62 | 222.250 | 2.8656 | 11.20 | 19.10 | .66 | 5242. | .019 | 150.0 | .0740 | 587.3 | .13 | 1001. |
|------------------|--------|---------|--------|-------|-------|------|---------|------|-------|-------|-------|------|--------|
| PROPANE | 507.21 | 147.253 | .0325 | .13 | 18.15 | .06 | 471. | .000 | .2 | .0001 | .6 | .01 | 85. |
| ISO BUTAE | 562.56 | 119.798 | .0041 | .02 | 17.24 | .47 | 3754. | .000 | .2 | .0001 | .6 | .08 | 647. |
| N-BUTANE | 583.84 | 110.623 | .0117 | .05 | 17.23 | .15 | 1306. | .000 | .2 | .0001 | .6 | .03 | 225. |
| LIGHT GASOLINE | 740.51 | 59.400 | .0017 | .01 | 14.74 | 2.22 | 17615. | .000 | .3 | .0002 | 1.2 | .33 | 2594. |
| HEAVY GASOLINE | 833.66 | 44.400 | .0015 | .01 | 13.60 | 2.51 | 19918. | .000 | .3 | .0002 | 1.2 | .34 | 2709. |
| HYDRO TRT LT KER | 827.17 | 39.400 | .0014 | .01 | 13.44 | 4.05 | 32170. | .000 | .5 | .0002 | 1.8 | .54 | 4324. |
| HYDRO TRT HY KER | 852.10 | 34.400 | .0019 | .01 | 13.74 | 2.99 | 23717. | .000 | .5 | .0002 | 1.8 | .41 | 3258. |
| HT COAL GAS OIL | 936.81 | 19.400 | .0041 | .02 | 11.78 | 3.27 | 25956. | .000 | 1.1 | .0005 | 4.2 | .39 | 3059. |
| TOTAL OUTPUT | | | 16.43 | | | | 130132. | .02 | 153. | .38 | 599. | 2.26 | 17903. |

LOSS AND UNACCOUNTED FOR

~~COAL OIL HYDRO CRACKER~~ ~~ENERGY CONSUMPTION~~ REPORT

| STREAM | KG/SEC | (LBS/HR) | MM BLS/KG | (BTU/LB) | MILLION JOULES/SEC | (BTU/HR) | (8BL F0E) (PER HR) | PCT REFINERY INPUT |
|----------|--------|----------|-----------|----------|-----------------------|----------|-------------------------|-----------------------|
| STEAM | 3.5 | 27556.7 | 2.9 | 1195.0 | 9.7 | 32.9 | 5.4 | .137 |
| FUEL | .4 | 3137.4 | 48.8 | 21300.0 | 19.3 | 65.9 | 10.9 | .274 |
| POWER | | | | | 5.4 | 18.6 | 3.1 | .077 |
| HYDROGEN | .4 | 3160.4 | 120.2 | 51667.0 | 46.3 | 158.1 | 26.1 | .658 |
| TOTALS | | | | | 80.7 | 275.5 | 45.5 | 1.147 |

CATALYTIC REFORMER MATERIAL BALANCE REPORT

| FEED STREAMS | KG/H 3 (API) | WT PCT SULFUR | WT PCT NITROGEN | WT PCT HYDROGEN | KG/SEC STREAM | KG/SEC (LBS/HR) STREAM | KG/SEC SULFUR | KG/SEC (LBS/HR) SULFUR | KG/SEC NITROGEN | KG/SEC (LBS/HR) NITROGEN | KG/SEC HYDROGEN | KG/SEC (LBS/HR) HYDROGEN |
|-----------------|----------------|------------------|--------------------|--------------------|------------------|---------------------------|------------------|---------------------------|--------------------|-----------------------------|--------------------|-----------------------------|
| HEAVY NAPHTHA | 789.18 | 47.629 | .1132 | .03 | 13.81 | 8.95 | 71046. | .011 | 84.0 | .0028 | 22.6 | 1.24 |
| HEAVY GASOLINE | 784.56 | 43.583 | .0055 | .01 | 14.23 | 5.21 | 41360. | .000 | 2.3 | .0005 | 4.1 | .74 |
| HEAVY GASOLINE | 804.30 | 44.260 | .4179 | .59 | 13.44 | .78 | 6219. | .003 | 26.0 | .0046 | 36.7 | .11 |
| TOTAL INPUT | | | | | | 14.95 | 118624. | .01 | 112. | .01 | 63. | 2.08 |
| | | | | | | | | | | | | 16533. |

PRODUCT STREAMS

| | | | | | | | | | | | | |
|--------------------------|--------|---------|--------|------|--------|-------|---------|-------|------|--------|------|--------|
| HYDROGEN | 334.48 | 291.140 | 0.0000 | 0.00 | 100.00 | .26 | 2046. | 0.000 | 0.0 | 0.0600 | 0.0 | .26 |
| ETHANE AND LIR | 399.62 | 222.250 | .9477 | .51 | 21.89 | .97 | 7696. | .009 | 72.9 | .0032 | 41.2 | .21 |
| PROPANE | 507.21 | 147.208 | .9950 | .11 | 18.13 | 1.09 | 8586. | .002 | 16.8 | .0012 | 9.5 | .20 |
| ISO BUTANE | 582.58 | 119.788 | .3013 | .17 | 17.16 | .47 | 3725. | .001 | 11.2 | .0008 | 6.3 | .08 |
| N-BUTANE | 583.84 | 110.629 | .1976 | .11 | 17.19 | .74 | 5886. | .001 | 11.2 | .0008 | 6.3 | .13 |
| LIGHT GASOLINE | 778.87 | 50.000 | 0.0000 | 0.00 | 13.46 | 5.17 | 41025. | 0.000 | 0.0 | 0.0000 | 0.0 | .70 |
| HEAVY GASOLINE | 864.61 | 32.000 | 0.0000 | 0.00 | 11.91 | 5.57 | 44235. | 0.000 | 0.0 | 0.0000 | 0.0 | .66 |
| TOTAL OUTPUT | | | | | | 14.26 | 113194. | .01 | 112. | .01 | 63. | 2.23 |
| LOSS AND UNACCOUNTED FOR | | | | | | .68 | 5431. | .00 | 0. | .00 | 0. | -.15 |
| | | | | | | | | | | | | -1193. |

CATALYTIC REFORMER ENERGY CONSUMPTION REPORT

| STREAM | KG/SEC (LBS/HR) | MM JLS/KG (BTU/LB) | MILLION JOULES/SEC (BTU/HR) | (88L FOE) (PER HR) | PCT REFINERY INPUT |
|----------|--------------------|-----------------------|-----------------------------------|-------------------------|-----------------------|
| FUEL | 1.1 | 8914.8 | 48.8 | 21000.0 | 54.9 |
| POWER | | | | | 1.3 |
| HYDROGEN | .3 | 2045.7 | 120.2 | 51667.0 | 31.0 |
| TOTALS | | | | | 87.1 |
| | | | | | 30.9 |
| | | | | | .7 |
| | | | | | 17.5 |
| | | | | | 49.1 |
| | | | | | 1.237 |

BUTANE ISOMERIZER MATERIAL BALANCE REPORT

| FEED STREAMS | KG/M 3 (API) | WT PCT SULFUR | WT PCT NITROGEN | WT PCT HYDROGEN | KG/SEC STREAM | KG/SEC (LBS/HR) STREAM | KG/SEC SULFUR | KG/SEC NITROGEN | KG/SEC (LBS/HR) SULFUR | KG/SEC NITROGEN | KG/SEC (LBS/HR) HYDROGEN | KG/SEC (LBS/HR) HYDROGEN |
|-----------------|----------------|------------------|--------------------|--------------------|------------------|---------------------------|------------------|--------------------|---------------------------|--------------------|-----------------------------|-----------------------------|
| N-BUTANE | 503.84 | 110.629 | .1000 | .10 | 17.21 | 1.07 | 8517. | .001 | 8.5 | .0011 | 8.5 | .18 1466. |
| TOTAL INPUT | | | | | 1.07 | 8517. | .00 | 9. | .00 | 9. | .18 1466. | |

PRODUCT STREAMS

| | | | | | | | | | | | | |
|--------------------------|--------|---------|--------|------|-------|-------|-------|-------|-----|--------|-----------|-----------|
| ETHANE AND LTR | 399.62 | 222.250 | 0.0000 | 0.00 | 22.22 | .01 | 52. | 0.000 | 0.0 | 0.0000 | 0.0 | .00 11. |
| PROPANE | 537.21 | 147.208 | 0.0000 | 0.00 | 13.18 | .01 | 46. | 0.000 | 0.0 | 0.0000 | 0.0 | .00 8. |
| ISO BUTANE | 562.56 | 119.788 | .1022 | .10 | 17.21 | 1.05 | 8333. | .001 | 8.5 | .0011 | 8.5 | .18 1434. |
| TOTAL OUTPUT | | | | | 1.06 | 8431. | .00 | 9. | .00 | 9. | .18 1454. | |
| LOSS AND UNACCOUNTED FOR | | | | | .01 | 86. | .00 | 0. | .00 | 0. | .00 12. | |

BUTANE ISOMERIZER ENERGY CONSUMPTION REPORT

| STREAM | KG/SEC | (LBS/HR) | MM JLS/KG | (BTU/LB) | MILLION JOULES/SEC | (BTU/HR) | (BBL F0E) (PER HR) | PCT REFINERY INPUT |
|--------|--------|----------|-----------|----------|-----------------------|----------|-------------------------|-----------------------|
| STEAM | .3 | 2:09.5 | 2.8 | 1195.0 | .7 | 2.5 | .4 | .010 |
| FUEL | .0 | 144.0 | 48.8 | 21000.0 | .9 | 3.0 | .5 | .013 |
| POWER | | | | | .1 | .2 | .0 | .001 |
| TOTALS | | | | | 1.7 | 5.8 | 1.0 | .024 |

ALKYLATION UNIT MATERIAL BALANCE REPORT

| FEED STREAMS | KG/M 3 (API) | WT PCT | | WT PCT | | KG/SEC (LBS/HR) | | KG/SEC (LBS/HR) | | KG/SEC (LBS/HR) | | KG/SEC (LBS/HR) | | KG/SEC (LBS/HR) | |
|--------------------------|----------------|---------|----------|----------|--------|-----------------|----------|-----------------|--------|-----------------|----------|-----------------|--------|-----------------|----------|
| | | SULFUR | NITROGEN | HYDROGEN | STREAM | SULFUR | NITROGEN | HYDROGEN | STREAM | SULFUR | NITROGEN | HYDROGEN | STREAM | SULFUR | NITROGEN |
| ISO BUTANE | 562.56 | 119.789 | .1000 | 17.21 | .53 | 4206. | .001 | 4.2 | .0005 | 4.2 | .0005 | 4.2 | .09 | 724. | |
| BUTYLENE | 604.42 | 102.384 | .1000 | 14.26 | .49 | 3916. | .000 | 3.9 | .0005 | 3.9 | .0005 | 3.9 | .07 | 558. | |
| TOTAL INPUT | | | 1.02 | 8121. | | | .00 | 8. | .00 | | | 8. | .16 | 1282. | |
| PRODUCT STREAMS | | | | | | | | | | | | | | | |
| LIGHT ALKYLATE | 701.56 | 70.000 | .0317 | 16.66 | .97 | 7713. | .000 | 2.4 | .0003 | 2.4 | .0003 | 2.4 | .16 | 1285. | |
| HEAVY ALKYLATE | 738.19 | 63.000 | 1.32 | 15.75 | .05 | 432. | .001 | 5.7 | .0007 | 5.7 | .0007 | 5.7 | .01 | 68. | |
| TOTAL OUTPUT | | | 1.03 | 8146. | | | .00 | 8. | .00 | | | 8. | .17 | 1353. | |
| LOSS AND UNACCOUNTED FOR | | | | | | | | | | | | | | | |
| | | | -.00 | -25. | | | -.00 | -0. | -.00 | | | -0. | -.01 | -71. | |

ENERGY CONSUMPTION REPORT

| STREAM | ALKYLATION UNIT | | ENERGY CONSUMPTION REPORT | | PCT REFINERY INPUT | |
|--------|-----------------|----------|---------------------------|------------------|--------------------|------|
| | KG/SEC | (LBS/HR) | MM JLS/KG (BTU/LB) | MILLION (BTU/HR) | (BBL FOE) (PER HR) | |
| STEAM | 2.3 | 18240.5 | 2.8 | 1195.0 | 3.6 | .091 |
| POWER | | | | .7 | .4 | .010 |
| TOTALS | | | 7.1 | 24.2 | 4.0 | .101 |

POLYMERIZATION UNIT MATERIAL BALANCE REPORT

| FEED STREAMS | KG/M 3 (API) | WT PCT SULFUR | WT PCT NITROGEN | WT PCT HYDROGEN | KG/SEC STREAM | KG/SEC SULFUR | KG/SEC NITROGEN | KG/SEC HYDROGEN | (LBS/HR) SULFUR | (LBS/HR) NITROGEN | (LBS/HR) HYDROGEN | KG/SEC HYDROGEN | KG/SEC HYDROGEN |
|-----------------|----------------|------------------|--------------------|--------------------|------------------|------------------|--------------------|--------------------|--------------------|----------------------|----------------------|--------------------|--------------------|
| PROPYLENE | 521.50 | 139.573 | .10 | 14.26 | .74 | .001 | 5.9 | .0007 | 5.9 | .11 | 838. | .11 | 838. |
| BUTYLENE | 604.42 | 132.384 | .10 | 14.26 | .00 | .000 | .0 | .0030 | .0 | .00 | 0. | .00 | 0. |
| TOTAL INPUT | | | | | .74 | .00 | 6. | .00 | 6. | .11 | 838. | | |

PRODUCT STREAMS

| | | | | | | | | | | | | | |
|--------------------------|--------|---------|-----|-------|------|------|-----|-------|-----|------|------|--|--|
| N-BUTANE | 583.84 | 110.629 | .05 | 17.22 | .67 | .000 | .3 | .0000 | .3 | .01 | 102. | | |
| POLY GASOLINE | 778.87 | 50.000 | .10 | 13.70 | .72 | .001 | 5.6 | .0007 | 5.6 | .10 | 778. | | |
| TOTAL OUTPUT | | | | | .79 | .00 | 6. | .00 | 6. | .11 | 881. | | |
| LOSS AND UNACCOUNTED FOR | | | | | -.05 | -.00 | -0. | -.00 | -0. | -.01 | -43. | | |

POLYMERIZATION UNIT ENERGY CONSUMPTION REPORT

| STREAM | KG/SEC | (LBS/HR) | MM JLS/KG | (BTU/LB) | MILLION JOULES/SEC | (BTU/HR) | (BBL FUEL PER HR) | PCT REFINERY INPUT |
|--------|--------|----------|-----------|----------|-----------------------|----------|----------------------|-----------------------|
| STEAM | .2 | 1338.8 | 2.8 | 1195.0 | .5 | 1.6 | .3 | .007 |
| POWER | | | | | .1 | .5 | .1 | .002 |
| TOTALS | | | | | .6 | 2.1 | .3 | .009 |

HYDROGEN PLANT MATERIAL BALANCE REPORT

| FEED STREAMS | KG/M 3 (API) | WT PCT SULFUR | WT PCT NITROGEN | WT PCT HYDROGEN | KG/SEC STREAM | KG/SEC (LBS/HR) STREAM | KG/SEC (LBS/HR) SULFUR | KG/SEC (LBS/HR) NITROGEN | KG/SEC (LBS/HR) HYDROGEN | KG/SEC (LBS/HR) HYDROGEN | KG/SEC (LBS/HR) HYDROGEN |
|-----------------|----------------|------------------|--------------------|--------------------|------------------|---------------------------|---------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|
| ETHANE AND LTR | 399.62 | 222.250 | 0.00 | 22.22 | .17 | 1322. | 0.000 | 0.0 | 0.0000 | 0.0 | .04 |
| PROPANE | 507.21 | 147.238 | 0.00 | 18.18 | 1.80 | 14332. | 0.000 | 0.0 | 0.0000 | 0.0 | .33 |
| TOTAL INPUT | | | | | 1.97 | 15623. | 0.00 | 0.0 | 0.00 | 0.0 | .36 |

PRODUCT STREAMS

| | | | | | | | | | | | |
|--------------------------|--------|---------|------|--------|------|-------|-------|-----|--------|-----|------|
| HYDROGEN | 334.48 | 291.140 | 0.00 | 100.00 | 1.09 | 8641. | 0.000 | 0.0 | 0.0000 | 0.0 | 1.09 |
| TOTAL OUTPUT | | | | | 1.09 | 8641. | 0.00 | 0.0 | 0.00 | 0.0 | 1.09 |
| LOSS AND UNACCOUNTED FOR | | | | | .83 | 6983. | 0.00 | 0.0 | 0.00 | 0.0 | -.72 |

-5747.

ENERGY CONSUMPTION REPORT

| STREAM | KG/SEC | (LBS/HR) | MM BLS/KG | (BTU/LB) | JOULES/SEC | (MILLION) | (BBL F0E) | (PER HR) | PCT REFINERY INPUT |
|--------|--------|----------|-----------|----------|------------|-----------|-----------|----------|-----------------------|
| STEAM | -2.5 | -20414.0 | 2.8 | 1195.0 | -7.1 | -24.4 | -4.0 | | -.102 |
| FUEL | 2.1 | 17003.9 | 48.8 | 21000.0 | 104.7 | 357.1 | 59.0 | | 1.486 |
| POWER | | | | | .6 | 2.0 | .3 | | .008 |
| TOTALS | | | | | 98.1 | 334.7 | 55.3 | | 1.393 |

TOTAL JET FUEL BLEND AT 525 DEG F ENDPOINT

| PROCESS UNIT ORIGIN | METER 3 /DAY | STREAM NAME | COMP (BPD) | VOL PCT | KG/H3 (API) | SULFUR WT PCT | NITROGEN WT PCT | HYDROGEN WT PCT | VISCOSITY BLD INDEX |
|-------------------------|-----------------|------------------|---------------|---------|----------------|------------------|--------------------|--------------------|------------------------|
| SHALE KERO HYDROTREATER | 110. | HYDRO TRI LT KER | 689. | 4.3 | 804. | 44.3 | .01 | .0099 | 14.13 |
| SHALE OIL HYDRO CRACKER | 166. | HYDRO TRI LT KER | 1045. | 6.6 | 811. | 42.9 | .01 | .0335 | 13.92 |
| GAS OIL HYDRO CRACKER | 70. | HYDRO TRI LT KER | 443. | 2.8 | 814. | 42.1 | .01 | .0028 | 13.82 |
| KEROSENEHYDRO TREATER | 76. | HYDRO TRI LT KER | 480. | 3.0 | 817. | 41.5 | .04 | .0004 | 13.73 |
| CRUDE UNIT(PETROLEUM) | 523. | LIGHT KEROSENE | 3290. | 20.7 | 820. | 41.0 | .40 | .0040 | 13.60 |
| COAL OILHYDRO CRACKER | 424. | HYDRO TRI LT KER | 2666. | 16.8 | 827. | 39.4 | .00 | .0056 | 13.44 |
| COAL KERO HYDROTREATER | 134. | HYDRO TRI LT KER | 840. | 5.3 | 856. | 33.6 | .00 | .0029 | 12.62 |
| CRUDE UNIT(SHALE) | 292. | LIGHT KEROSENE | 1837. | 11.6 | 853. | 34.3 | .66 | 1.0100 | 12.20 |
| CRUDE UNIT(COAL) | 731. | LIGHT KEROSENE | 4601. | 29.0 | 923. | 21.6 | .09 | .2900 | 10.80 |
| POOL | 2527. | | 15891. | 100.0 | 855.2 | 33.8 | .19 | .2115 | 12.54 |
| | | | | | | | | | 0.3 |

| PROCESS UNIT ORIGIN | METER 3 /DAY | STREAM NAME | COMP (BPD) | VOL PCT | DEG C | FREEZING PT (DEG F) | SMK PT MM | PT | PARA WT PCT | NAPHTH WT PCT | AROM WT PCT | HEAT OF COMBUSTION JLS/KG (BTU/LB) |
|-------------------------|-----------------|------------------|---------------|---------|-------|------------------------|--------------|----|----------------|------------------|----------------|---------------------------------------|
| SHALE KERO HYDROTREATER | 110. | HYDRO TRI LT KER | 689. | 4.3 | -41.7 | -43.0 | 29.1 | | 45.0 | 49.9 | 5.1 | 18740. |
| SHALE OIL HYDRO CRACKER | 166. | HYDRO TRI LT KER | 1045. | 6.6 | -45.6 | -50.0 | 25.3 | | 50.0 | 32.0 | 18.0 | 18691. |
| GAS OIL HYDRO CRACKER | 70. | HYDRO TRI LT KER | 443. | 2.8 | -45.6 | -50.0 | 23.8 | | 50.0 | 40.0 | 10.0 | 18666. |
| KEROSENEHYDRO TREATER | 76. | HYDRO TRI LT KER | 480. | 3.0 | -29.4 | -21.0 | 22.6 | | 50.1 | 25.2 | 24.7 | 18637. |
| CRUDE UNIT(PETROLEUM) | 523. | LIGHT KEROSENE | 3290. | 20.7 | -29.4 | -21.0 | 23.0 | | 47.7 | 26.3 | 26.0 | 18480. |
| COAL OILHYDRO CRACKER | 424. | HYDRO TRI LT KER | 2666. | 16.8 | -48.3 | -55.0 | 19.5 | | 50.0 | 30.0 | 20.0 | 18566. |
| COAL KERO HYDROTREATER | 134. | HYDRO TRI LT KER | 840. | 5.3 | -52.8 | -63.0 | 15.2 | | 30.0 | 55.0 | 15.0 | 18322. |
| CRUDE UNIT(SHALE) | 292. | LIGHT KEROSENE | 1837. | 11.6 | -49.0 | -40.0 | 14.0 | | 30.0 | 53.0 | 17.0 | 18290. |
| CRUDE UNIT(COAL) | 731. | LIGHT KEROSENE | 4601. | 29.0 | -51.1 | -60.0 | 8.0 | | 20.0 | 30.0 | 50.0 | 17860. |
| POOL | 2527. | | 15891. | 100.0 | -38.3 | -37.0 | 13.9 | | 36.6 | 34.3 | 29.1 | 18303. |

JET FUEL BLEND AT 525 DEG F ENDPOINT AND HYDROGEN CONTENT SPECIFICATION OF 12.80 WT PERCENT

| PROCESS UNIT ORIGIN | STREAM NAME | METER 3 /DAY | (BPD) | COMP VOL PCT | KG/M3 (API) | SULFUR WT PCT | NITROGEN WT PCT | HYDROGEN WT PCT | VISCOSITY BLO INDEX |
|-------------------------|------------------|-----------------|--------|-----------------|-------------|------------------|--------------------|--------------------|------------------------|
| SHALE KERO HYDROTREATER | HYDRO TRT LT KER | 110. | 689. | 4.9 | 804. | 44.3 | .01 | .0099 | 14.13 |
| SHALE OIL HYDRO CRACKER | HYDRO TRT LT KER | 166. | 1045. | 7.5 | 811. | 42.9 | .01 | .0335 | 13.92 |
| GAS OIL HYDRO CRACKER | HYDRO TRT LT KER | 70. | 443. | 3.2 | 814. | 42.1 | .01 | .0028 | 13.82 |
| KEROSENEHYDRO TREATER | HYDRO TRT LT KER | 76. | 480. | 3.4 | 817. | 41.5 | .04 | .0004 | 13.73 |
| CRUDE UNIT(PETROLEUM) | LIGHT KEROSENE | 523. | 3290. | 23.6 | 820. | 41.0 | .40 | .0040 | 13.60 |
| COAL OILHYDRO CRACKER | HYDRO TRT LT KER | 424. | 2666. | 19.1 | 827. | 39.4 | .00 | .0056 | 13.44 |
| COAL KERO HYDROTREATER | HYDRO TRT LT KER | 134. | 840. | 6.0 | 836. | 33.6 | .00 | .0029 | 12.62 |
| CRUDE UNIT(SHALE) | LIGHT KEROSENE | 292. | 1837. | 13.2 | 833. | 34.3 | .66 | 1.0100 | 12.20 |
| CRUDE UNIT(COAL) | LIGHT KEROSENE | 424. | 2665. | 19.1 | 923. | 21.6 | .09 | .2900 | 10.80 |
| POOL | | 2219. | 13956. | 100.0 | 845.7 | 33.6 | .20 | .1996 | 12.80 |

| PROCESS UNIT ORIGIN | STREAM NAME | METER 3 /DAY | (BPD) | COMP VOL PCT | DEG C | (DEG F) | SHK PT MM | PT | PARA WT PCT | NAPHTH WT PCT | AROM WT PCT | HEAT OF COMBUSTION JLS/KG (BTU/LB) |
|-------------------------|------------------|-----------------|--------|-----------------|-------|---------|--------------|----|----------------|------------------|----------------|---------------------------------------|
| SHALE KERO HYDROTREATER | HYDRO TRT LT KER | 110. | 689. | 4.9 | -41.7 | -43.0 | 29.1 | | 45.0 | 49.9 | 5.1 | 18740. |
| SHALE OIL HYDRO CRACKER | HYDRO TRT LT KER | 166. | 1045. | 7.5 | -45.6 | -50.0 | 25.3 | | 50.0 | 32.0 | 18.0 | 18691. |
| GAS OIL HYDRO CRACKER | HYDRO TRT LT KER | 70. | 443. | 3.2 | -45.6 | -50.0 | 23.8 | | 50.0 | 40.0 | 10.0 | 18666. |
| KEROSENEHYDRO TREATER | HYDRO TRT LT KER | 76. | 480. | 3.4 | -29.4 | -21.0 | 22.6 | | 50.1 | 25.2 | 24.7 | 18637. |
| CRUDE UNIT(PETROLEUM) | LIGHT KEROSENE | 523. | 3290. | 23.6 | -29.4 | -21.0 | 23.0 | | 47.7 | 26.3 | 26.0 | 18480. |
| COAL OILHYDRO CRACKER | HYDRO TRT LT KER | 424. | 2666. | 19.1 | -48.3 | -55.0 | 19.5 | | 50.0 | 30.0 | 20.0 | 18566. |
| COAL KERO HYDROTREATER | HYDRO TRT LT KER | 134. | 840. | 6.0 | -52.8 | -63.0 | 15.2 | | 30.0 | 55.0 | 15.0 | 18322. |
| CRUDE UNIT(SHALE) | LIGHT KEROSENE | 292. | 1837. | 13.2 | -43.0 | -40.0 | 14.0 | | 30.0 | 53.0 | 17.0 | 18290. |
| CRUDE UNIT(COAL) | LIGHT KEROSENE | 424. | 2665. | 19.1 | -51.1 | -60.0 | 8.0 | | 20.0 | 30.0 | 50.0 | 17860. |
| POOL | | 2219. | 13956. | 100.0 | -37.2 | -34.9 | 15.4 | | 39.1 | 35.0 | 25.9 | 18370. |

TOTAL JET FUEL BLEND AT 653 DEG ENOPOINT

| PROCESS UNIT ORIGIN | STREAM NAME | METER 3 /DAY | COMP | | SULFUR | | NITROGEN | | HYDROGEN | | VISCOSITY | |
|-------------------------|------------------|-----------------|--------|---------|--------|--------|----------|--------|----------|--------|-----------|--|
| | | | (BPD) | VOL PCT | (API) | WT PCT | WT PCT | WT PCT | WT PCT | WT PCT | BLD INDEX | |
| SHALE KERO HYDROTREATER | HYDRO TRT LT KER | 116. | 689. | 1.9 | 8J4. | 44.3 | .61 | .0099 | 14.13 | 0.0 | 0.0 | |
| SHALE OIL HYDRO CRACKER | HYDRO TRT LT KER | 166. | 1045. | 2.9 | 811. | 42.9 | .01 | .0335 | 13.92 | 0.0 | 0.0 | |
| SHALE OIL HYDRO CRACKER | HYDRO TRT HY KER | 89. | 560. | 1.6 | 835. | 37.9 | .02 | .0607 | 13.84 | 8.0 | 8.0 | |
| GAS OIL HYDRO CRACKER | HYDRO TRT LT KER | 70. | 443. | 1.2 | 814. | 42.1 | .01 | .0028 | 13.82 | 0.0 | 0.0 | |
| COAL OILHYDRO CRACKER | HYDRO TRT HY KER | 303. | 1908. | 5.4 | 852. | 34.4 | .00 | .0076 | 13.74 | 8.0 | 8.0 | |
| KEROSENEHYDRO TREATER | HYDRO TRT LT KER | 76. | 480. | 1.3 | 817. | 41.5 | .04 | .0004 | 13.73 | 0.0 | 0.0 | |
| SHALE KERO HYDROTREATER | HYDRO TRT HY KER | 234. | 1471. | 4.1 | 818. | 37.1 | .01 | .0197 | 13.70 | 8.0 | 8.0 | |
| GAS OIL HYDRO CRACKER | DESUL HYKER | 70. | 443. | 1.2 | 853. | 34.1 | .01 | .0027 | 13.66 | 8.0 | 8.0 | |
| CRUDE UNIT(PETROLEUM) | LIGHT KEROSENE | 523. | 3290. | 9.2 | 820. | 41.0 | .40 | .0000 | 13.60 | 0.0 | 0.0 | |
| DISTILLATE DESULFURIZER | DESUL HYKER | 34. | 212. | .6 | 844. | 36.0 | .03 | .0005 | 13.49 | 8.0 | 8.0 | |
| COAL OILHYDRO CRACKER | HYDRO TRT LT KER | 424. | 2666. | 7.5 | 827. | 39.4 | .00 | .0056 | 13.44 | 0.0 | 0.0 | |
| CRUDE UNIT(PETROLEUM) | HEAVY KEROSENE | 425. | 2671. | 7.5 | 854. | 34.0 | .93 | .0100 | 13.13 | 8.0 | 8.0 | |
| COAL KERO HYDROTREATER | HYDRO TRT LT KER | 134. | 840. | 2.4 | 836. | 33.6 | .00 | .0029 | 12.62 | 0.0 | 0.0 | |
| COAL KERO HYDROTREATER | HYDRO TRT HY KER | 210. | 1320. | 3.7 | 887. | 27.9 | .00 | .0032 | 12.27 | 8.0 | 8.0 | |
| CRUDE UNIT(SHALE) | LIGHT KEROSENE | 292. | 1837. | 5.2 | 853. | 34.3 | .66 | 1.0100 | 12.20 | 0.0 | 0.0 | |
| CRUDE UNIT(SHALE) | HEAVY KEROSENE | 623. | 3928. | 11.0 | 831. | 27.1 | .69 | 1.9009 | 11.50 | 6.0 | 6.0 | |
| CRUDE UNIT(COAL) | LIGHT KEROSENE | 731. | 4601. | 12.9 | 923. | 21.6 | .09 | .2900 | 10.80 | 0.0 | 0.0 | |
| CRUDE UNIT(COAL) | HEAVY KEROSENE | 1149. | 7226. | 20.3 | 959. | 15.9 | .14 | .3200 | 10.40 | 5.0 | 5.0 | |
| POOL | | 5663. | 35621. | 100.0 | 880.1 | 29.1 | .26 | .3771 | 12.13 | 3.6 | 3.6 | |

| PROCESS UNIT ORIGIN | STREAM NAME | METER 3 /DAY | COMP (BPD) | VOL PCT | FREEZING PT (DEG F) | SMK PT MM | PARA WT PCT | NAPHTH WT PCT | AROM WT PCT | HEAT OF COMBUSTION JLS/KG (BTU/LB) | |
|-------------------------|------------------|-----------------|---------------|---------|------------------------|--------------|----------------|------------------|----------------|---------------------------------------|--------|
| SHALE KERO HYDROTREATER | HYDRO TRT LT KER | 116. | 689. | 1.9 | -41.7 | -43.0 | 23.8 | 45.0 | 49.9 | 5.1 | 18666. |
| SHALE OIL HYDRO CRACKER | HYDRO TRT LT KER | 166. | 1045. | 2.9 | -45.6 | -50.0 | 19.5 | 50.0 | 32.0 | 18.0 | 18566. |
| SHALE OIL HYDRO CRACKER | HYDRO TRT HY KER | 89. | 560. | 1.6 | -45.6 | -50.0 | 32.4 | 50.0 | 32.0 | 18.0 | 18738. |
| GAS OIL HYDRO CRACKER | HYDRO TRT LT KER | 70. | 443. | 1.2 | -45.6 | -50.0 | 23.0 | 50.0 | 43.0 | 10.0 | 18480. |
| COAL OILHYDRO CRACKER | HYDRO TRT HY KER | 303. | 1908. | 5.4 | -43.3 | -55.0 | 22.8 | 50.0 | 30.0 | 20.0 | 18606. |
| KEROSENEHYDRO TREATER | HYDRO TRT LT KER | 76. | 480. | 1.3 | -29.4 | -21.0 | 25.3 | 50.1 | 25.2 | 24.7 | 18691. |
| SHALE KERO HYDROTREATER | HYDRO TRT HY KER | 234. | 1471. | 4.1 | -11.1 | 12.0 | 29.6 | 45.0 | 49.9 | 5.1 | 18713. |
| GAS OIL HYDRO CRACKER | DESUL HYKER | 70. | 443. | 1.2 | -43.6 | -50.0 | 22.3 | 50.0 | 40.0 | 10.0 | 18594. |
| CRUDE UNIT(PETROLEUM) | LIGHT KEROSENE | 523. | 3290. | 9.2 | -23.4 | -21.0 | 23.0 | 47.7 | 26.3 | 26.0 | 18480. |
| DISTILLATE DESULFURIZER | DESUL HYKER | 34. | 212. | .6 | -3.9 | 25.0 | 26.3 | 50.1 | 25.2 | 24.7 | 18662. |
| COAL OILHYDRO CRACKER | HYDRO TRT LT KER | 424. | 2666. | 7.5 | -3.3 | -25.0 | 15.2 | 50.0 | 30.0 | 20.0 | 18322. |
| CRUDE UNIT(PETROLEUM) | HEAVY KEROSENE | 425. | 2671. | 7.5 | -3.9 | 25.0 | 20.0 | 47.7 | 26.3 | 26.0 | 18350. |
| COAL KERO HYDROTREATER | HYDRO TRT LT KER | 134. | 840. | 2.4 | -52.8 | -63.0 | 22.6 | 30.0 | 55.0 | 15.0 | 18637. |
| COAL KERO HYDROTREATER | HYDRO TRT HY KER | 210. | 1320. | 3.7 | -33.3 | -28.0 | 16.0 | 30.0 | 55.0 | 15.0 | 18315. |
| CRUDE UNIT(SHALE) | LIGHT KEROSENE | 292. | 1837. | 5.2 | -40.0 | -40.0 | 14.0 | 30.0 | 53.0 | 17.0 | 18290. |
| CRUDE UNIT(SHALE) | HEAVY KEROSENE | 623. | 3928. | 11.0 | -9.4 | 15.0 | 12.0 | 30.0 | 53.0 | 17.0 | 18100. |
| CRUDE UNIT(COAL) | LIGHT KEROSENE | 731. | 4601. | 12.9 | -51.1 | -60.0 | 8.0 | 20.0 | 30.0 | 50.0 | 17860. |
| CRUDE UNIT(COAL) | HEAVY KEROSENE | 1149. | 7226. | 20.3 | -31.7 | -25.0 | 7.0 | 20.0 | 30.0 | 50.0 | 17580. |
| POOL | | 5663. | 35621. | 100.0 | -21.9 | -7.4 | 12.1 | 34.2 | 36.0 | 29.8 | 18152. |

LET FINE: 31 ENC AT 65.1 DEG F FNDPOINT AND HYDROGEN CONTENT SPECIFICATION OF 12.80 WT PERCENT

| PROCESS UNIT ORIGIN | STREAM NAME | METER 3 /DAY | (BPD) | COMP VOL PCT | KG/H3 (API) | SULFUR | | NITROGEN | | HYDROGEN | | VISCOSITY | |
|-------------------------|------------------|-----------------|--------|-----------------|-------------|--------|--------|----------|--------|----------|--------|-----------|-----------|
| | | | | | | WT PCT | WT PCT | WT PCT | WT PCT | WT PCT | WT PCT | BLD INDEX | BLD INDEX |
| SHALE KERO HYDROTREATER | HYDRO TRT LT KER | 110. | 689. | 2.7 | 804. | 44.3 | .01 | .0039 | 14.13 | 0.0 | 0.0 | 0.0 | |
| SHALE OIL HYDRO CRACKER | HYDRO TRT LT KER | 166. | 1045. | 4.0 | 811. | 42.9 | .01 | .0335 | 13.92 | 0.0 | 0.0 | 0.0 | |
| SHALE OIL HYDRO CRACKER | HYDRO TRT HY KER | 89. | 560. | 2.2 | 835. | 37.9 | .02 | .0607 | 13.94 | 8.0 | 8.0 | 8.0 | |
| GAS OIL HYDRO CRACKER | HYDRO TRT LT KER | 70. | 443. | 1.7 | 814. | 42.1 | .01 | .0628 | 13.82 | 0.0 | 0.0 | 0.0 | |
| COAL OILHYDRO CRACKER | HYDRO TRT HY KER | 303. | 1908. | 7.3 | 832. | 34.4 | .00 | .0076 | 13.74 | 8.0 | 8.0 | 8.0 | |
| KEROSENEHYDRO TREATER | HYDRO TRT LT KER | 76. | 480. | 1.8 | 817. | 41.5 | .04 | .0004 | 13.73 | 0.0 | 0.0 | 0.0 | |
| SHALE KERO HYDROTREATER | HYDRO TRT HY KER | 234. | 1471. | 5.7 | 838. | 37.1 | .01 | .0187 | 13.70 | 8.0 | 8.0 | 8.0 | |
| GAS OIL HYDRO CRACKER | DESUL HYKER | 70. | 443. | 1.7 | 853. | 34.1 | .01 | .0027 | 13.66 | 8.0 | 8.0 | 8.0 | |
| CRUDE UNIT(PETROLEUM) | LIGHT KEROSENE | 523. | 3290. | 12.7 | 820. | 41.0 | .40 | .0040 | 13.60 | 0.0 | 0.0 | 0.0 | |
| DISTILLATE DESULFURIZER | DESUL HYKER | 34. | 212. | .8 | 844. | 36.0 | .05 | .0005 | 13.49 | 8.0 | 8.0 | 8.0 | |
| COAL OILHYDRO CRACKER | HYDRO TRT LT KER | 424. | 2666. | 10.3 | 827. | 39.4 | .00 | .0056 | 13.44 | 0.0 | 0.0 | 0.0 | |
| CRUDE UNIT(PETROLEUM) | HEAVY KEROSENE | 425. | 2671. | 10.3 | 854. | 34.0 | .95 | .0100 | 13.10 | 8.0 | 8.0 | 8.0 | |
| COAL KERO HYDROTREATER | HYDRO TRT LT KER | 134. | 840. | 3.2 | 856. | 33.6 | .00 | .0029 | 12.62 | 0.0 | 0.0 | 0.0 | |
| COAL KERO HYDROTREATER | HYDRO TRT HY KER | 210. | 1320. | 5.1 | 887. | 27.9 | .00 | .0032 | 12.27 | 8.0 | 8.0 | 8.0 | |
| CRUDE UNIT(SHALE) | LIGHT KEROSENE | 292. | 1837. | 7.1 | 853. | 34.3 | .66 | 1.0100 | 12.20 | 0.0 | 0.0 | 0.0 | |
| CRUDE UNIT(SHALE) | HEAVY KEROSENE | 623. | 3918. | 15.1 | 891. | 27.1 | .69 | 1.9009 | 11.50 | 6.0 | 6.0 | 6.0 | |
| CRUDE UNIT(COAL) | LIGHT KEROSENE | 346. | 2179. | 8.4 | 923. | 21.6 | .09 | .2900 | 10.80 | 0.0 | 0.0 | 0.0 | |
| P00- | | -129. | 25973. | 100.0 | 854.0 | 34.0 | .31 | .4037 | 12.80 | 3.5 | 3.5 | 3.5 | |

| PROCESS UNIT ORIGIN | | STREAM NAME | METER 3 /DAY | COMP (BPD) | VOL PCT | FREEZING PT (DEG F) | SHK PT MM | PARA WT PCT | NAPHTH WT PCT | AROM WT PCT | HEAT OF COMBUSTION JLS/KG (BTU/LB) |
|-------------------------|------------------|-------------|-----------------|---------------|---------|------------------------|--------------|----------------|------------------|----------------|---------------------------------------|
| SHALE KERO HYDROTREATER | HYDRO TRT LT KER | 110. | 689. | 2.7 | -41.7 | -43.0 | 23.8 | 45.0 | 49.9 | 5.1 | 18666. |
| SHALE OIL HYDRO CRACKER | HYDRO TRT LT KER | 166. | 1045. | 4.0 | -45.6 | -50.0 | 19.5 | 50.0 | 32.0 | 18.0 | 18566. |
| SHALE OIL HYDRO CRACKER | HYDRO TRT HY KER | 89. | 560. | 2.2 | -45.6 | -50.0 | 32.4 | 50.0 | 32.0 | 18.0 | 18738. |
| GAS OIL HYDRO CRACKER | HYDRO TRT LT KER | 76. | 443. | 1.7 | -45.6 | -50.0 | 23.0 | 50.0 | 40.0 | 10.0 | 18480. |
| COAL OIL HYDRO CRACKER | HYDRO TRT HY KER | 303. | 1908. | 7.3 | -48.3 | -55.0 | 22.6 | 50.0 | 34.0 | 20.0 | 18606. |
| KEROSENE HYDRO TREATER | HYDRO TRT LT KER | 76. | 480. | 1.8 | -29.4 | -21.0 | 25.3 | 50.1 | 25.2 | 24.7 | 18691. |
| SHALE KERO HYDROTREATER | HYDRO TRT HY KER | 254. | 1471. | 5.7 | -11.1 | 12.0 | 29.6 | 45.0 | 49.9 | 5.1 | 18713. |
| GAS OIL HYDRO CRACKER | DESUL HYKER | 70. | 443. | 1.7 | -45.6 | -50.0 | 22.3 | 50.0 | 40.0 | 10.0 | 18594. |
| CRUDE UNIT (PETROLEUM) | LIGHT KEROSENE | 523. | 3290. | 12.7 | -29.4 | -21.0 | 23.0 | 47.7 | 26.3 | 26.0 | 18480. |
| DISTILLATE DESULFURIZER | DESUL HYKER | 34. | 212. | 8 | -3.9 | 25.0 | 26.3 | 50.1 | 25.2 | 24.7 | 18662. |
| COAL OIL HYDRO CRACKER | HYDRO TRT LT KER | 425. | 2666. | 10.3 | -48.3 | -55.0 | 15.2 | 50.0 | 30.0 | 20.0 | 18322. |
| CRUDE UNIT (PETROLEUM) | HEAVY KEROSENE | 425. | 2671. | 10.3 | -3.9 | 25.0 | 20.0 | 47.7 | 26.3 | 26.0 | 18350. |
| COAL KERO HYDROTREATER | HYDRO TRT LT KER | 134. | 840. | 3.2 | -52.8 | -63.0 | 22.6 | 30.0 | 55.0 | 15.0 | 18637. |
| COAL KERO HYDROTREATER | HYDRO TRT HY KER | 210. | 1320. | 5.1 | -33.3 | -28.0 | 16.0 | 30.0 | 55.0 | 15.0 | 18315. |
| CRUDE UNIT (SHALE) | LIGHT KEROSENE | 292. | 1837. | 7.1 | -43.0 | -40.0 | 14.0 | 30.0 | 53.0 | 17.0 | 18290. |
| CRUDE UNIT (SHALE) | HEAVY KEROSENE | 623. | 3918. | 15.1 | -9.4 | 15.0 | 12.0 | 30.0 | 53.0 | 17.0 | 18100. |
| CRUDE UNIT (COAL) | LIGHT KEROSENE | 346. | 2179. | 8.4 | -51.1 | -60.0 | 8.0 | 20.0 | 30.0 | 50.0 | 17860. |
| | | 4129. | 25973. | 100.0 | -18.8 | -1.9 | 16.2 | 40.1 | 38.5 | 21.4 | 18360. |

TOTAL JET FUEL BLEND AT 600.0 DEG F ENDPOINT

| PROCESS UNIT ORIGIN | STREAM NAME | METER 3 /DAY | (BPD) | COMP VOL PCT | KG/M3 (API) | SULFUR WT PCT | NITROGEN WT PCT | HYDROGEN WT PCT | VISCOSITY BLD INDEX |
|-------------------------|------------------|-----------------|--------|-----------------|-------------|------------------|--------------------|--------------------|------------------------|
| SHALE KERO HYDROTREATER | HYDRO TRT LT KER | 250. | 1572. | 5.7 | 825. | 39.9 | .01 | .0152 | 4.8 |
| SHALE OIL HYDRO CRACKER | HYDRO TRT LT KER | 220. | 1381. | 5.0 | 825. | 39.8 | .01 | .0498 | 4.8 |
| GAS OIL HYDRO CRACKER | HYDRO TRT LT KER | 113. | 709. | 2.6 | 838. | 37.3 | .01 | .0028 | 4.8 |
| COAL OIL HYDRO CRACKER | HYDRO TRT LT KER | 606. | 3811. | 13.7 | 842. | 36.4 | .00 | .0068 | 4.8 |
| KEROSENE HYDRO TREATER | HYDRO TRT LT KER | 97. | 607. | 2.2 | 833. | 38.2 | .05 | .0005 | 4.8 |
| CRUDE UNIT (PETROLEUM) | LIGHT KEROSENE | 778. | 4893. | 17.6 | 840. | 36.7 | .73 | .0076 | 4.8 |
| COAL KERO HYDROTREATER | HYDRO TRT LT KER | 259. | 1632. | 5.9 | 875. | 30.1 | .00 | .0031 | 4.8 |
| CRUDE UNIT (SHALE) | LIGHT KEROSENE | 666. | 4188. | 15.1 | 876. | 29.9 | .68 | 1.5445 | 3.6 |
| CRUDE UNIT (COAL) | LIGHT KEROSENE | 1421. | 8937. | 32.2 | 945. | 18.1 | .12 | .3080 | 3.0 |
| POOL | | 4409. | 27729. | 100.0 | 879.8 | 29.2 | .27 | .3444 | 4.0 |

| PROCESS UNIT ORIGIN | STREAM NAME | METER 3 /DAY | (BPD) | COMP VOL PCT | DEG C | FREEZING PT (DEG F) | SHK PT MM | PT | HEAT OF COMBUSTION JLS/KG (BTU/LB) |
|-------------------------|------------------|-----------------|--------|-----------------|-------|------------------------|--------------|------|---------------------------------------|
| SHALE KERO HYDROTREATER | HYDRO TRT LT KER | 250. | 1572. | 5.7 | -23.3 | -10.0 | 22.6 | 45.0 | 43. 18484. |
| SHALE OIL HYDRO CRACKER | HYDRO TRT LT KER | 220. | 1381. | 5.0 | -43.6 | -50.0 | 14.9 | 50.0 | 42. 18193. |
| GAS OIL HYDRO CRACKER | HYDRO TRT LT KER | 113. | 709. | 2.6 | -45.6 | -50.0 | 16.3 | 50.0 | 43. 18303. |
| COAL OIL HYDRO CRACKER | HYDRO TRT LT KER | 606. | 3811. | 13.7 | -48.3 | -55.0 | 16.1 | 50.0 | 42. 18033. |
| KEROSENE HYDRO TREATER | HYDRO TRT LT KER | 97. | 607. | 2.2 | -14.1 | 6.6 | 21.4 | 50.1 | 43. 18609. |
| CRUDE UNIT (PETROLEUM) | LIGHT KEROSENE | 778. | 4893. | 17.6 | -14.1 | 6.6 | 21.2 | 47.7 | 43. 18402. |
| COAL KERO HYDROTREATER | HYDRO TRT LT KER | 259. | 1632. | 5.9 | -41.1 | -42.0 | 17.6 | 30.0 | 43. 18366. |
| CRUDE UNIT (SHALE) | LIGHT KEROSENE | 666. | 4188. | 15.1 | -21.7 | -7.0 | 12.8 | 30.0 | 42. 18176. |
| CRUDE UNIT (COAL) | LIGHT KEROSENE | 1421. | 8937. | 32.2 | -33.4 | -39.0 | 7.4 | 20.0 | 41. 17692. |
| POOL | | 4409. | 27729. | 100.0 | -25.4 | -13.7 | 11.9 | 34.8 | 42. 18068. |

JET FUEL BLEND AT 600.0 DEG F ENDPOINT AND HYDROGEN CONTENT SPECIFICATION OF 12.90 WT PERCENT

| PROCESS UNIT ORIGIN | STREAM NAME | METER 3 /DAY | COMP (BPD) | VOL PCT | KG/H3 (API) | SULFUR WT PCT | NITROGEN WT PCT | HYDROGEN WT PCT | VISCOSITY BLD INDEX |
|-------------------------|------------------|-----------------|---------------|---------|-------------|------------------|--------------------|--------------------|------------------------|
| SHALE KERO HYDROTREATER | HYDRO TRT LT KER | 250. | 1572. | 7.6 | 825. | 39.9 | .01 | .0152 | 13.88 |
| SHALE OIL HYDRO CRACKER | HYDRO TRT LT KER | 220. | 1381. | 6.7 | 825. | 39.8 | .01 | .0498 | 13.87 |
| GAS OIL HYDRO CRACKER | HYDRO TRT LT KER | 113. | 709. | 3.4 | 838. | 37.3 | .01 | .0028 | 13.72 |
| COAL OIL HYDRO CRACKER | HYDRO TRT LT KER | 606. | 3811. | 18.4 | 842. | 36.4 | .00 | .0068 | 13.62 |
| KEROSENEHYDRO TREATER | HYDRO TRT LT KER | 97. | 607. | 2.9 | 833. | 38.2 | .03 | .0005 | 13.59 |
| CRUDE UNIT(PETROLEUM) | LIGHT KEROSENE | 778. | 4893. | 23.7 | 840. | 36.7 | .73 | .0076 | 13.30 |
| COAL KERO HYDROTREATER | HYDRO TRT LT KER | 259. | 1632. | 7.9 | 875. | 30.1 | .00 | .0031 | 12.41 |
| CRUDE UNIT(SHALE) | LIGHT KEROSENE | 666. | 4186. | 20.3 | 876. | 29.9 | .68 | 1.5445 | 11.78 |
| CRUDE UNIT(COAL) | LIGHT KEROSENE | 297. | 1867. | 9.0 | 945. | 18.1 | .12 | .3080 | 10.56 |
| POOL | | 3285. | 20659. | 100.0 | 857.5 | 33.4 | .33 | .3591 | 12.80 |

4.4

| PROCESS UNIT ORIGIN | STREAM NAME | METER 3 /DAY | COMP (BPD) | VOL PCT | DEG C | FREEZING PT (DEG F) | SMK PT MM | PT WT | PARA WT PCT | NAPHTH WT PCT | AROM WT PCT | HEAT OF COMBUSTION JLS/KG (BTU/LB) |
|-------------------------|------------------|-----------------|---------------|---------|-------|------------------------|--------------|----------|----------------|------------------|----------------|---------------------------------------|
| SHALE KERO HYDROTREATER | HYDRO TRT LT KER | 250. | 1572. | 7.6 | -23.3 | -10.0 | 22.6 | 45.0 | 49.9 | 5.1 | 43. | 18484. |
| SHALE OIL HYDRO CRACKER | HYDRO TRT LT KER | 220. | 1381. | 6.7 | -45.6 | -50.0 | 14.9 | 50.0 | 32.0 | 18.0 | 42. | 18193. |
| GAS OIL HYDRO CRACKER | HYDRO TRT LT KER | 113. | 709. | 3.4 | -45.6 | -50.0 | 16.3 | 50.0 | 40.0 | 10.0 | 43. | 18303. |
| COAL OIL HYDRO CRACKER | HYDRO TRT LT KER | 606. | 3811. | 18.4 | -48.3 | -55.0 | 16.1 | 50.0 | 30.0 | 20.0 | 42. | 18033. |
| KEROSENEHYDRO TREATER | HYDRO TRT LT KER | 97. | 607. | 2.9 | -14.1 | 6.6 | 21.4 | 50.1 | 25.2 | 24.7 | 43. | 18609. |
| CRUDE UNIT(PETROLEUM) | LIGHT KEROSENE | 778. | 4893. | 23.7 | -14.1 | 6.6 | 21.2 | 47.7 | 26.3 | 26.0 | 43. | 18402. |
| COAL KERO HYDROTREATER | HYDRO TRT LT KER | 259. | 1632. | 7.9 | -41.1 | -42.0 | 17.5 | 30.0 | 55.0 | 15.0 | 43. | 18366. |
| CRUDE UNIT(SHALE) | LIGHT KEROSENE | 666. | 4186. | 20.3 | -21.7 | -7.0 | 12.8 | 30.0 | 53.0 | 17.0 | 42. | 18176. |
| CRUDE UNIT(COAL) | LIGHT KEROSENE | 297. | 1867. | 9.0 | -39.4 | -39.3 | 7.4 | 20.0 | 30.0 | 50.0 | 41. | 17692. |
| POOL | | 3285. | 20659. | 100.0 | -22.4 | -8.4 | 15.0 | 40.4 | 37.7 | 21.9 | 42. | 18210. |

4.4

TOTAL MIDDLE DISTILLATE FUEL OIL BLEND
(INCLUDING JET FUEL COMPONENTS)

| PROCESS UNIT ORIGIN | STREAM NAME | METER 3 /DAY | (BPD) | COMP | | SULFUR WT PCT | NITROGEN WT PCT | HYDROGEN WT PCT | VISCOSITY | |
|-------------------------|------------------|-----------------|--------|-------|-----------------|------------------|--------------------|--------------------|-----------|-------|
| | | | | VOL | PCT KG/H3 (API) | | | | BLO | INDEX |
| COAL KERO HYDROTREATER | HYDRO TRT LT KER | 134. | 843. | 2.3 | 856. | 33.6 | .00 | .0029 | 12.62 | 0.0 |
| COAL KERO HYDROTREATER | HYDRO TRT HY KER | 210. | 1320. | 3.6 | 837. | 27.9 | .00 | .0032 | 12.27 | 0.0 |
| COAL OILHYDRO CRACKER | HYDRO TRT LT KER | 424. | 2666. | 7.2 | 827. | 39.4 | .00 | .0056 | 13.44 | 0.0 |
| COAL GILHYDRO CRACKER | HYDRO TRT HY KER | 303. | 1908. | 5.2 | 852. | 34.4 | .00 | .0076 | 13.74 | 8.0 |
| SHALE KERO HYDROTREATER | HYDRO TRT LT KER | 110. | 689. | 1.9 | 814. | 44.3 | .01 | .0099 | 14.13 | 0.0 |
| SHALE KERO HYDROTREATER | HYDRO TRT HY KER | 234. | 1471. | 4.0 | 838. | 37.1 | .01 | .0187 | 13.70 | 8.0 |
| SHALE OIL HYDRO CRACKER | HYDRO TRT LT KER | 166. | 1045. | 2.3 | 811. | 42.9 | .01 | .0335 | 13.92 | 0.0 |
| GAS OIL HYDRO CRACKER | DESUL HYKER | 70. | 443. | 1.2 | 853. | 34.1 | .01 | .0027 | 13.66 | 8.0 |
| GAS OIL HYDRO CRACKER | HYDRO TRT LT KER | 76. | 443. | 1.2 | 814. | 42.1 | .01 | .0028 | 13.82 | 0.0 |
| SHALE OIL HYDRO CRACKER | HYDRO TRT HY KER | 89. | 560. | 1.5 | 835. | 37.9 | .02 | .0607 | 13.84 | 8.0 |
| KEROSENEHYDRO TREATER | HYDRO TRT LT KER | 76. | 480. | 1.3 | 817. | 41.5 | .04 | .0004 | 13.73 | 0.0 |
| DISTILLATE DESULFURIZER | DESUL HYKER | 34. | 212. | .6 | 844. | 36.0 | .05 | .0035 | 13.49 | 8.0 |
| DISTILLATE DESULFURIZER | DESUL LTCYCLE | 43. | 268. | .7 | 837. | 28.0 | .08 | .0199 | 11.96 | 8.0 |
| CRUDE UNIT(COAL) | LIGHT KEROSENE | 731. | 4601. | 12.5 | 923. | 21.6 | .09 | .2900 | 10.80 | 0.0 |
| CRUDE UNIT(COAL) | HEAVY KEROSENE | 1149. | 7226. | 19.6 | 959. | 15.9 | .14 | .3200 | 10.40 | 5.0 |
| CRUDE UNIT(PETROLEUM) | LIGHT KEROSENE | 523. | 3290. | 8.9 | 820. | 41.0 | .40 | .0040 | 13.60 | 0.0 |
| GAS OIL DESULFURIZER | DISTILLATE | 1. | 5. | .0 | 843. | 36.3 | .48 | .6612 | 13.12 | 8.0 |
| CRUDE UNIT(SHALE) | LIGHT KEROSENE | 292. | 1837. | 5.0 | 853. | 34.3 | .66 | 1.0100 | 12.20 | 0.0 |
| CRUDE UNIT(SHALE) | HEAVY KEROSENE | 623. | 3918. | 10.6 | 891. | 27.1 | .69 | 1.9009 | 11.50 | 6.0 |
| CRUDE UNIT(PETROLEUM) | HEAVY KEROSENE | 425. | 2671. | 7.2 | 854. | 34.0 | .95 | .0100 | 13.10 | 8.0 |
| GAS OIL DESULFURIZER | DISTILLATE | 2. | 10. | .0 | 829. | 39.0 | 1.40 | .0628 | 13.53 | 8.0 |
| CATALYTIC CRACKER | LIGHT CYCLE OIL | 160. | 1064. | 2.7 | 898. | 26.0 | 1.57 | .3823 | 11.49 | 10.0 |
| POOL | | 3868. | 36908. | 100.0 | 880.8 | 29.0 | .29 | .3746 | 12.11 | 3.8 |

TOTAL RESIDUAL FUEL OIL BLEND

| PROCESS UNIT ORIGIN | STREAM NAME | METER 3 /DAY | (BPD) | COMP | | SULFUR NITROGEN | | HYDROGEN | | VISCOSITY | |
|-------------------------|-----------------|-----------------|--------|---------|-------------|-----------------|--------|----------|--------|-----------|-----------|
| | | | | VOL PCT | KG/M3 (API) | WT PCT | WT PCT | WT PCT | WT PCT | BLD INDEX | BLD INDEX |
| COAL OIL/HYDRO CRACKER | HT COAL GAS OIL | 302. | 1899. | 5.1 | 937. | 19.4 | .00 | .0162 | 11.78 | 25.0 | 25.0 |
| SHALE OIL HYDRO CRACKER | HT SHALEGAS OIL | 284. | 1785. | 4.8 | 910. | 23.9 | .01 | .0407 | 12.55 | 25.0 | 25.0 |
| GAS OIL DESULFURIZER | DESUL GAS OIL | 10. | 62. | .2 | 919. | 22.3 | .07 | .0940 | 12.20 | 25.0 | 25.0 |
| GAS OIL DESULFURIZER | DESUL GAS OIL | 22. | 139. | .4 | 903. | 25.0 | .19 | .0114 | 12.63 | 25.0 | 25.0 |
| CRUDE UNIT(COAL) | VACUUM BOTTOMS | 1064. | 6694. | 17.9 | 1111. | -4.3 | .31 | 1.2200 | 8.50 | 24.2 | 24.2 |
| CRUDE UNIT(SHALE) | VACUUM BOTTOMS | 258. | 1623. | 4.4 | 1033. | 5.3 | .40 | 3.0600 | 9.40 | 31.8 | 31.8 |
| CRUDE UNIT(SHALE) | REDUCED CRUDE | 755. | 4750. | 12.7 | 957. | 16.2 | .57 | 2.1348 | 10.71 | 21.6 | 21.6 |
| CRUDE UNIT(SHALE) | SHALE GAS OIL | 2003. | 12600. | 33.8 | 947. | 17.9 | .60 | 1.9971 | 10.90 | 20.2 | 20.2 |
| THERMAL CRACKER | HEAVY FUEL | 133. | 834. | 2.2 | 915. | 23.0 | 1.77 | .1652 | 12.81 | 15.0 | 15.0 |
| CATALYTIC CRACKER | BOTTOMS | 55. | 597. | 1.6 | 1145. | -8.0 | 2.33 | .5689 | 8.15 | 21.0 | 21.0 |
| CRUDE UNIT(PETROLEUM) | REDUCED CRUDE | 666. | 4190. | 11.2 | 949. | 17.5 | 2.41 | .2657 | 11.73 | 22.6 | 22.6 |
| CRUDE UNIT(PETROLEUM) | VACUUM BOTTOMS | 338. | 2123. | 5.7 | 1022. | 6.8 | 3.67 | .5800 | 10.80 | 33.0 | 33.0 |
| POOL | | 5930. | 37296. | 160.0 | 985.6 | 11.9 | .91 | 1.3767 | 10.52 | 23.0 | 23.0 |

OVERALL OIL REFINERY MATERIAL BALANCE REPORT

INPUT STREAMS

| CRUDE NAME | FLOW RATE | | (BPD) | WEIGHT | | SULFUR | | NITROGEN | | HYDROGEN | |
|--------------------|-------------|--------|--------|--------|----------|--------|----------|----------|----------|----------|----------|
| | METER 3/DAY | KG/SEC | | KG/SEC | (LBS/HR) | KG/SEC | (LBS/HR) | KG/SEC | (LBS/HR) | KG/SEC | (LBS/HR) |
| AGA JARI IRAN | 5246.6 | 51.7 | 33000. | 51.7 | 410469. | .7 | 5500. | .1 | 534. | 6.7 | 53361. |
| PARAHO SHALE OIL | 5246.6 | 56.9 | 33000. | 56.9 | 451297. | .4 | 3204. | 1.1 | 9026. | 6.5 | 51899. |
| SYNTHOIL KY COAL | 5246.6 | 62.4 | 33000. | 62.4 | 495310. | .1 | 1090. | .5 | 3913. | 5.8 | 45668. |
| TOTAL CRUDE OILS | 15739.7 | 171.0 | 99000. | 171.0 | 1357076. | 1.2 | 9794. | 1.7 | 13473. | 19.0 | 150928. |
| PURCHASED HYDROGEN | | 0. | | 0. | 0. | | | | | | |
| TOTAL INPUT | 15739.7 | 171.0 | 99000. | 171.0 | 1357076. | 1.2 | 9794. | 1.7 | 13473. | 19.0 | 150928. |

OUTPUT STREAMS

| | | | | | | | | | | | |
|--------------------|---------|-------|---------|-------|----------|-----|-------|-----|--------|------|---------|
| SULFUR REMOVAL | 0.0 | .3 | 2247. | .3 | 2247. | 0.0 | 3063. | .4 | 3063. | .6 | 4458. |
| NITROGEN REMOVAL | 0.0 | 0. | 3063. | 0. | 3063. | 0.0 | 0. | 0.0 | 0. | 0. | 8. |
| REFINERY GAS MAKE | 328.8 | 2.5 | 20060. | 2.5 | 20060. | 0.0 | 0. | 0.0 | 0. | 0. | 0. |
| LPG PRODUCT | 1.2 | 7. | 56. | 7. | 56. | 0.0 | 0. | 0.0 | 0. | 0. | 0. |
| GASOLINE POOL | 3766.0 | 32.4 | 257154. | 32.4 | 257154. | .3 | 2068. | .0 | 45. | 4.6 | 36365. |
| SPECIFIED JET FUEL | 3284.5 | 32.6 | 258441. | 32.6 | 258441. | .1 | 841. | .1 | 926. | 4.2 | 33080. |
| MIDDLE DISTILLATE | 2583.4 | 27.2 | 215686. | 27.2 | 215686. | .1 | 555. | .1 | 851. | 3.1 | 24329. |
| RESIDUAL FUEL OIL | 5929.6 | 67.6 | 536350. | 67.6 | 536350. | .6 | 4859. | .9 | 7384. | 7.1 | 56412. |
| EXPORT NAPHTHA | 0.0 | 0. | 0. | 0. | 0. | 0.0 | 0. | 0.0 | 0. | 0.0 | 0. |
| COKE PRODUCT | 221.0 | 2.7 | 21799. | 2.7 | 21799. | .0 | 264. | .0 | 374. | .1 | 436. |
| KEROSENE SALE | 79.5 | .8 | 5960. | .8 | 5960. | .0 | 2. | .0 | 0. | .1 | 818. |
| DIESEL SALE | 79.5 | .8 | 6156. | .8 | 6156. | .0 | 3. | .0 | 0. | .1 | 831. |
| GAS OIL SALE | 0.0 | 0. | 0. | 0. | 0. | 0.0 | 0. | 0.0 | 0. | 0.0 | 0. |
| TOTAL OUTPUT | 16273.4 | 167.2 | 102357. | 167.2 | 1326373. | 1.1 | 8873. | 1.6 | 12642. | 19.2 | 152270. |

VOLUME RECOVERY = 103.391

WEIGHT RECOVERY = 97.782

SULFUR RECOVERY = 90.596

NITROGEN RECOVERY = 33.835

HYDROGEN RECOVERY = 133.890

SUMMARY OF REFINERY UNIT OPERATIONS

| UNIT | TOTAL FEED RATE | | TOTAL CAPACITY | |
|-------------------------|-----------------|---------|----------------|---------|
| | M3/DAY | (3PD) | M3/DAY | (3PD) |
| VAC OIST PETROLEUM | 1589.9 | 12000.0 | 1589.9 | 10000.0 |
| VAC OIST SHALE OIL | 3179.7 | 20000.0 | 3179.7 | 20000.0 |
| VAC OIST COAL OIL | 2959.1 | 18512.0 | 3179.7 | 20000.0 |
| FLUID COKER | 734.9 | 5000.0 | 734.9 | 5000.0 |
| CATALYTIC CRACKER | 1031.3 | 6486.7 | 4769.6 | 30000.0 |
| THERMAL CRACKER | 237.1 | 1431.4 | 1589.9 | 10000.0 |
| GAS OIL DESULFURIZER | 34.4 | 216.2 | 159.0 | 1000.0 |
| GAS OIL HYDRO CRACKER | 171.9 | 1081.1 | 734.9 | 5000.0 |
| SHALE OIL HYDRO CRACKER | 734.9 | 5000.0 | 734.9 | 5000.0 |
| COAL OIL HYDRO CRACKER | 1385.1 | 8712.0 | 1589.9 | 10000.0 |
| DISTILLATE HYDROCRACKER | 159.0 | 1000.0 | 159.0 | 1000.0 |
| DISTILLATE DESULFURIZER | 159.0 | 1000.0 | 159.0 | 1000.0 |
| KEROSENEHYDRO TREATER | 159.0 | 1000.0 | 159.0 | 1000.0 |
| SHALE KERO HYDROTREATER | 318.0 | 2000.0 | 318.0 | 2000.0 |
| COAL KERO HYDROTREATER | 318.0 | 2000.0 | 318.0 | 2000.0 |
| CATALYTIC REFORMER | 1639.9 | 10314.6 | 3179.7 | 20000.0 |
| ALKYLATION UNIT | 126.2 | 793.8 | 318.0 | 2000.0 |
| POLYMERIZATION UNIT | 79.5 | 500.0 | 79.5 | 500.0 |
| BUTANE ISOMERIZER | 159.0 | 1000.0 | 159.0 | 1000.0 |
| HYDROGENPLANT | 1.0 | 34.8 | 1.4 | 50.0 |

PROCESS UNIT SEVERITY LEVELS

| | |
|--|----------------------|
| CATALYTIC CRACKER GAS OIL CONVERSION | = 70.0 PERCENT |
| CATALYTIC REFORMER OCTANE | = 95.0 RON CLEAR |
| PETROLEUM GAS OIL HYDROCRACKER SEVERITY | = MID DIST OPERATION |
| SHALE OIL HYDROCRACKER SEVERITY LEVEL | = MEDIUM |
| COAL OIL HYDROCRACKER SEVERITY LEVEL | = MEDIUM |
| SHALE OIL KEROSENE HYDROTREATER SEVERITY | = MEDIUM |
| COAL OIL KEROSENE HYDROTREATER SEVERITY | = MEDIUM |

NOTE----- THE PROCESS SUMMARY GIVES THE HYDROGEN PLANT MAKE IN MILLIONS OF CUBIC METERS PER DAY AND MILLIONS OF STANDARD CUBIC FEET / DAY.

RATES SHOWN FOR THE ALKYLATION UNIT CORRESPOND TO THE TOTAL ALKYLATE MAKE.

RATES FOR THE POLYMERIZATION UNIT CORRESPOND TO THE POLYMER GASOLINE MAKE.

OVERALL ENERGY EFFICIENCY REPORT

| | MILLION JOULES/SEC | (MILLION) (BTU/HR) | (BBL FOE) (PER HOUR) | PCT REFINERY INPUT |
|----------|-----------------------|-----------------------|-------------------------|-----------------------|
| STEAM | 51.81 | 176.79 | 29.22 | .74 |
| FUEL | 442.97 | 1511.49 | 249.83 | 6.29 |
| POWER | 19.32 | 65.92 | 10.90 | .27 |
| TOTAL | 514.10 | 1754.20 | 289.95 | 7.30 |
| HYDROGEN | 192.09 | 655.44 | 108.34 | 2.73 |

OVERALL REFINERY ENERGY EFFICIENCY(EXCLUDES HYDROGEN)= 92.70 PERCENT

SUMMARY OF REFINERY FUEL AND POWER USAGE

| | VOLUME BLS FOE PER DAY |
|---|------------------------------|
| TOTAL INTERNAL REFINERY FUEL REQUIREMENT | 6878. |
| REFINERY GAS AVAILABILITY | 2068. |
| ADDITIONAL REFINERY FUEL REQUIREMENT | 4810. |
| REFINERY ELECTRICITY REQUIREMENT(THOUSANDS OF KWH)... | 464. |

GASOLINE POOL REPORT

| COMPONENT NAME | VOLUME (3PD) | VOLUME PERCENT | RESEARCH OCTANE NOS 0 ML TEL 3 ML TEL |
|-------------------|-----------------|-------------------|--|
| BUTANES | 2837. | 12.0 | 95.0 102.0 |
| PENTANES | 1114. | 4.7 | 70.9 89.8 |
| LT HYDROCRACKATE | 3067. | 12.9 | 84.5 98.0 |
| STR RUN GASOLINE | 3571. | 15.1 | 67.0 87.0 |
| CRACKER GASOLINE | 4138. | 17.5 | 92.0 98.0 |
| COKER/V3 GASOLINE | 505. | 2.1 | 70.0 90.5 |
| POLYMER GASOLINE | 500. | 2.1 | 96.0 100.5 |
| ALKYLATE | 794. | 3.4 | 93.5 138.3 |
| LT PLATFORMATE | 3510. | 15.2 | 92.0 100.0 |
| HVY PLATFORMATE | 3507. | 14.8 | 98.0 103.5 |
| DESULF GASOLINE | 46. | .2 | 70.0 80.5 |
| TOTAL POOL | 23688. | 100.0 | 87.1 97.5 |

SUMMARY OF OIL REFINERY ECONOMICS

1...INVESTMENT COSTS

| PROCESS UNIT | CU-MT/DAY | CAPACITY (BPD) | \$/CU-MT/DAY | INVESTMENT COSTS (\$/BBL/DAY) | INVESTMENT MILLIONS(\$) |
|---|-----------|----------------|--------------|-------------------------------|-------------------------|
| CRUDE UNIT(TOTAL) | 17108.4 | 107608.7 | 861. | 137. | 14.73 |
| VACUUM DIST(TOTAL) | 7949.3 | 50000.0 | 961. | 153. | 7.54 |
| CATALYTIC CRACKER | 4769.6 | 30000.0 | 4783. | 761. | 22.84 |
| THERMAL CRACKER | 1589.9 | 10000.0 | 1433. | 228. | 2.26 |
| KEROSENEHYDRO TREATER | 159.0 | 1000.0 | 2523. | 501. | .40 |
| GAS OIL DESULFURIZER | 159.0 | 1000.0 | 8445. | 1343. | 1.34 |
| DISTILLATE DESULFURIZER | 159.0 | 1000.0 | 3933. | 625. | .62 |
| FLUID COKER | 794.9 | 5000.0 | 7143. | 1135. | 5.68 |
| DISTILLATE HYDROCRACKER | 159.0 | 1000.0 | 9247. | 1476. | 1.47 |
| GAS OIL HYDRO CRACKER | 794.9 | 5000.0 | 8641. | 1278. | 6.39 |
| CATALYTIC REFORMER | 3179.7 | 20000.0 | 3415. | 543. | 10.86 |
| ALKYLATION UNIT | 318.0 | 2000.0 | 14285. | 2271. | 4.54 |
| POLYMERIZATION UNIT | 79.5 | 500.0 | 6732. | 1070. | .54 |
| BUTANE ISOMERIZER | 159.0 | 1000.0 | 2653. | 423. | .42 |
| HYDROGEN PLANT | 1.4 | 50.0 | 6302825. | 170000. | 8.50 |
| SHALE KERO HYDROTREATER | 318.0 | 2000.0 | 13643. | 2201. | 4.40 |
| COAL KERO HYDROTREATER | 318.0 | 2000.0 | 14167. | 2252. | 4.50 |
| SHALE OIL HYDRO CRACKER | 794.9 | 5000.0 | 8041. | 1278. | 6.39 |
| COAL OILHYDRO CRACKER | 1589.9 | 10000.0 | 6762. | 1075. | 10.75 |
| ONSITE INVESTMENT COSTS(PER CALENDER DAY BASIS) | | | | | 114.30 |
| ONSITE INVESTMENT COSTS(PER STREAM DAY BASIS) | | | | | 124.24 |
| THE REFINERY COMPLEXITY IS 5.40. OFFSITE FRACTION IS 1.35. OFFSITE INVESTMENT COSTS | | | | | 167.93 |
| TOTAL INVESTMENT COSTS | | | | | 292.17 |

NOTE---HYDROGEN PLANT RATES SHOWN IN THIS ECONOMIC SUMMARY ARE IN MILLIONS OF STANDARD CUBIC METERS AND STANDARD CUBIC FEET PER DAY.

2...OPERATING COSTS

2.1...FIXED COSTS

| PROCESS UNIT | CAPACITY | | COSTS (\$/DAY) | | UNIT TOTAL COSTS \$/DAY |
|-------------------------|-----------|-----------|----------------|-------------|----------------------------|
| | CU-MT/DAY | (BBL/DAY) | LABOR | MAINTENANCE | |
| CRUDE UNIT(TOTAL) | 17108. | 107509. | 806. | 1754. | 2560. |
| VACUUM DIST(TOTAL) | 7949. | 50000. | 1002. | 796. | 1798. |
| CATALYTIC CRACKER | 4770. | 50000. | 2545. | 2721. | 5266. |
| THERMAL CRACKER | 1590. | 10000. | 1245. | 373. | 1618. |
| KEROSENEHYDRO TREATER | 159. | 1000. | 720. | 48. | 768. |
| GAS OIL DESULFURIZER | 159. | 1000. | 720. | 160. | 880. |
| DISTILLATE DESULFURIZER | 159. | 1000. | 720. | 74. | 794. |
| FLUID COKER | 795. | 5000. | 1485. | 930. | 2415. |
| DISTILLATE HYDROCRACKER | 159. | 1000. | 1065. | 175. | 1240. |
| GAS OIL HYDRO CRACKER | 795. | 5000. | 1065. | 761. | 1826. |
| CATALYTIC REFORMER | 3180. | 20000. | 2013. | 1294. | 2306. |
| ALKYLATION UNIT | 318. | 2000. | 1050. | 744. | 1794. |
| POLYMERIZATION UNIT | 79. | 500. | 585. | 69. | 654. |
| BUTANE ISOMERIZER | 159. | 1000. | 1440. | 44. | 1484. |
| HYDROGENPLANT | 1. | 50. | 585. | 886. | 1471. |
| SHALE KERO HYDROTREATER | 318. | 2000. | 720. | 524. | 1244. |
| COAL KERO HYDROTREATER | 318. | 2000. | 720. | 537. | 1257. |
| SHALE OIL HYDRO CRACKER | 795. | 5000. | 1065. | 761. | 1826. |
| COAL OILHYDRO CRACKER | 1590. | 10000. | 1065. | 1281. | 2346. |
| TOTAL FIXED COSTS | | | | | 34606. |

2.2...VARIABLE COSTS(CATALYST,CHEMICALS AND WATER-EXCLUSIVE OF FUEL,POWER AND STEAM)

| PROCESS UNIT | FEEDRATE | | COSTS | | UNIT TOTAL COSTS \$/DAY |
|-------------------------|-----------|-----------|----------|----------|----------------------------|
| | CU-MT/DAY | (BBL/DAY) | \$/CU-MT | (\$/BBL) | |
| CRUDE UNIT(TOTAL) | 157434. | 99300. | .094 | .015 | 1485. |
| VACUUM DIST(TOTAL) | 7729. | 48612. | .120 | .019 | 924. |
| CATALYTIC CRACKER | 1631. | 6487. | .465 | .074 | 480. |
| THERMAL CRACKER | 237. | 1491. | .447 | .071 | 106. |
| KEROSENEHYDRO TREATER | 159. | 1000. | .541 | .086 | 86. |
| GAS OIL DESULFURIZER | 34. | 216. | .723 | .115 | 25. |
| DISTILLATE DESULFURIZER | 159. | 1000. | .723 | .115 | 115. |
| FLUID COKER | 795. | 5000. | .182 | .029 | 145. |
| DISTILLATE HYDROCRACKER | 159. | 1000. | 2.861 | .423 | 423. |
| GAS OIL HYDRO CRACKER | 172. | 1381. | 2.861 | .423 | 457. |
| CATALYTIC REFORMER | 1640. | 10315. | 1.151 | .183 | 1889. |
| ALKYLATION UNIT | 125. | 794. | 6.227 | .990 | 786. |
| POLYMERIZATION UNIT | 79. | 500. | 1.723 | .274 | 137. |
| BUTANE ISOMERIZER | 159. | 1000. | .270 | .043 | 43. |
| HYDROGENPLANT | 1. | 35. | 0.000 | .97.000 | 3513. |
| SHALE KERO HYDROTREATER | 318. | 2000. | 1.258 | .200 | 400. |
| COAL KERO HYDROTREATER | 318. | 2000. | 1.258 | .200 | 400. |
| SHALE OIL HYDRO CRACKER | 795. | 5000. | 2.661 | .423 | 2115. |
| COAL OILHYDRO CRACKER | 1385. | 8712. | 2.661 | .423 | 3685. |
| TOTAL VARIABLE COSTS | | | | | 17213. |

NOTE:--HYDROGEN PLANT RATES SHOWN IN THIS ECONOMIC SUMMARY ARE IN MILLIONS OF

2.3...POWER COSTS

| CENTS/KWH | THOUS-KWH/DAY | \$/DAY |
|-----------|---------------|--------|
| 2.5 | 464.1 | 11601. |

TOTAL ELECTRICITY USAGE

TOTAL OPERATING COSTS

63420.

3...CRUDE COSTS

| CRUDE OR PURCHASED BLENDING STOCKS | PRICE \$/CU-MT (\$/BBL) | CU-MT/DAY | VOLUME (BBL/DAY) | COST \$/DAY |
|---------------------------------------|----------------------------|-----------|---------------------|----------------|
| ACA JARI IRAN | 62.90 | 5247. | 33000. | 330000. |
| PARAHO SHALE OIL | 62.90 | 5247. | 33000. | 330000. |
| SYNTHOIL KY COAL | 62.90 | 5247. | 33000. | 330000. |

TOTAL VOLUME 15740. 99000.

TOTAL CRUDE COSTS 990000.

4...PRODUCT SALES

| PRODUCT | PRICE \$/CU-MT (\$/BBL) | CU-MT/DAY | VOLUME (BBL/DAY) | REVENUE \$/DAY |
|-----------------|----------------------------|-----------|---------------------|-------------------|
| FUEL GAS EXPORT | 56.62 | 329. | 2068. | 18613. |
| LPG | 66.34 | 1. | 7. | 78. |
| KEROSENE SALE | 92.77 | 79. | 500. | 7375. |
| DIESEL SALE | 86.49 | 79. | 500. | 6875. |
| GASOLINE | 103.67 | 3766. | 23688. | 397352. |
| JET FUEL BLEND | 103.64 | 3285. | 20639. | 330545. |
| DISTILLATE FUEL | 92.46 | 2583. | 16249. | 238858. |
| RESIDUAL FUEL | 77.36 | 5930. | 37296. | 458738. |
| COKE | 50.32 | 221. | 1390. | 11120. |
| TOTAL REVENUE | | | | 1470154. |

5...ECONOMIC SUMMARY

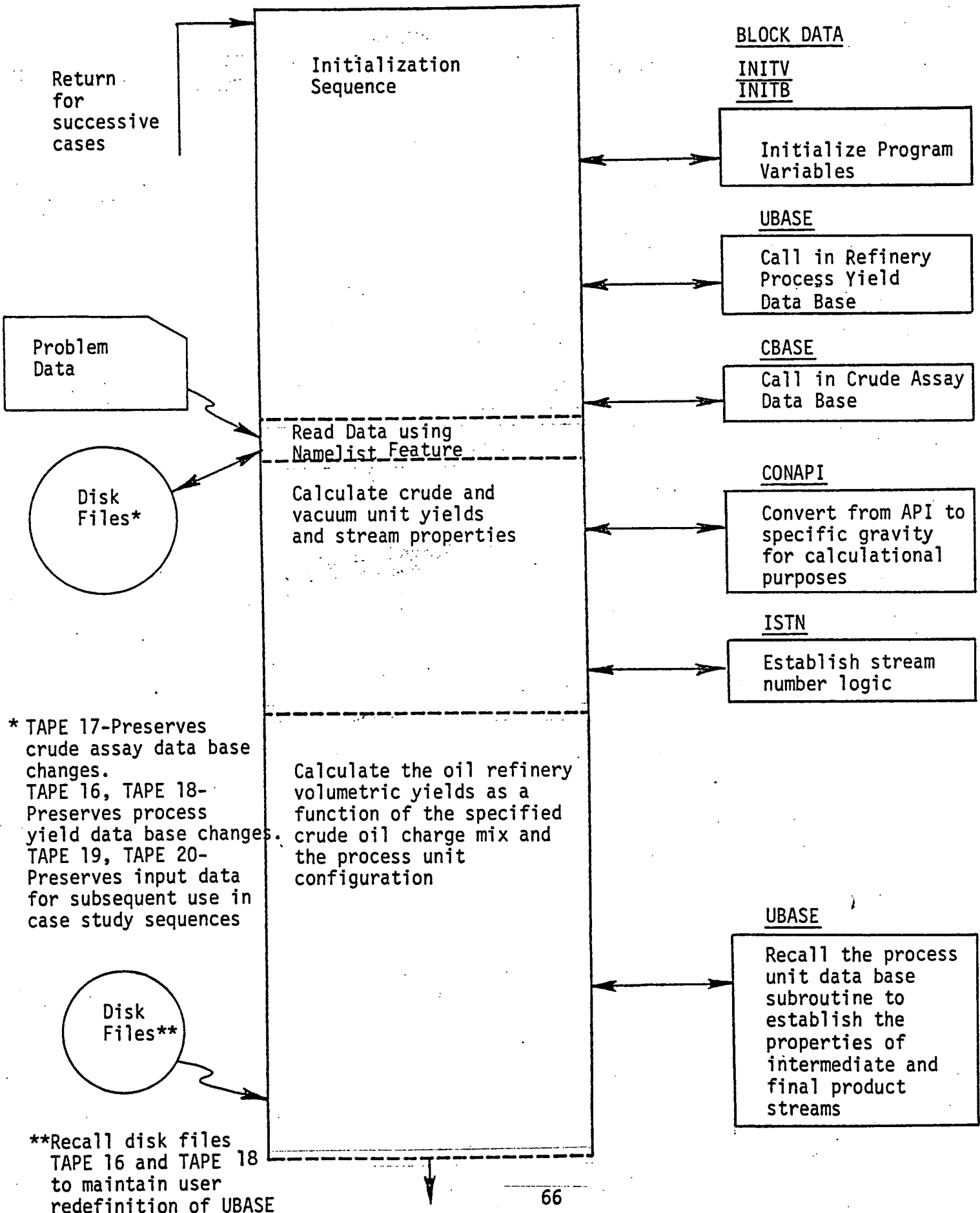
| | \$/DAY | \$/CU-MT CRUDE | \$/BBL CRUDE |
|-----------------------------|----------|-------------------|-----------------|
| REVENUE | 1470154. | 93.40 | 14.85 |
| OPERATING COSTS | 63420. | 4.03 | .64 |
| CRUDE COSTS | 990000. | 62.90 | 10.00 |
| NET PURCHASED FUEL | 43287. | 2.75 | .44 |
| GROSS PROFIT | 373447. | 23.73 | 3.77 |
| INVESTMENT CARRYING CHARGE* | 120069. | 7.63 | 1.21 |
| NET PROFIT | 253377. | 16.10 | 2.56 |

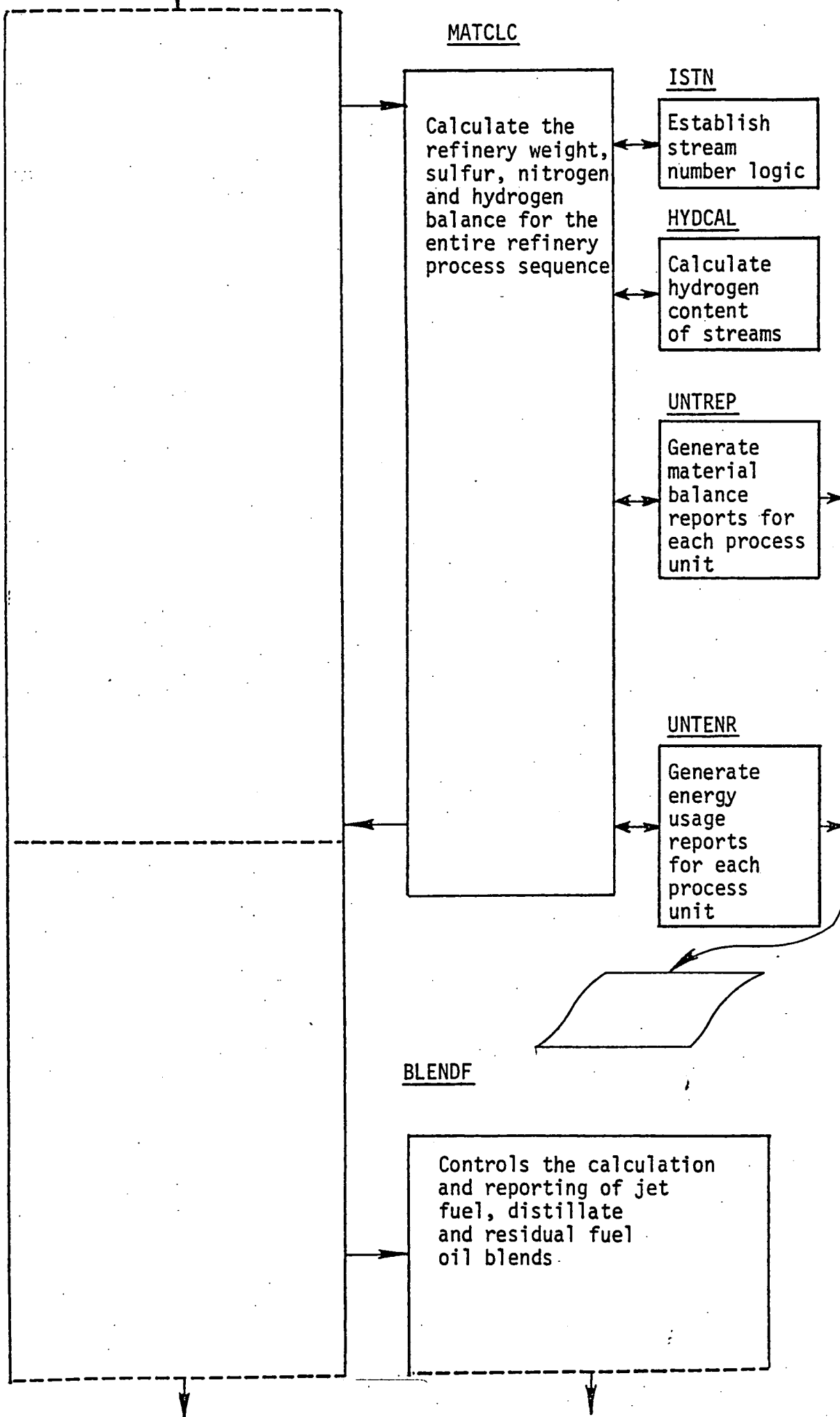
(NET FUEL PURCHASES OF 4810. BBL FUE/DAY AT 9.00\$/BFOE)

*INVESTMENT CARRYING RATE = 13.00 PERCENT

1...INPUT CARD IMAGES

**..AN END OF FILE HAS BEEN REACHED IN THE INPUT CARD STREAM-RUN TERMINATED

MAIN PROGRAM



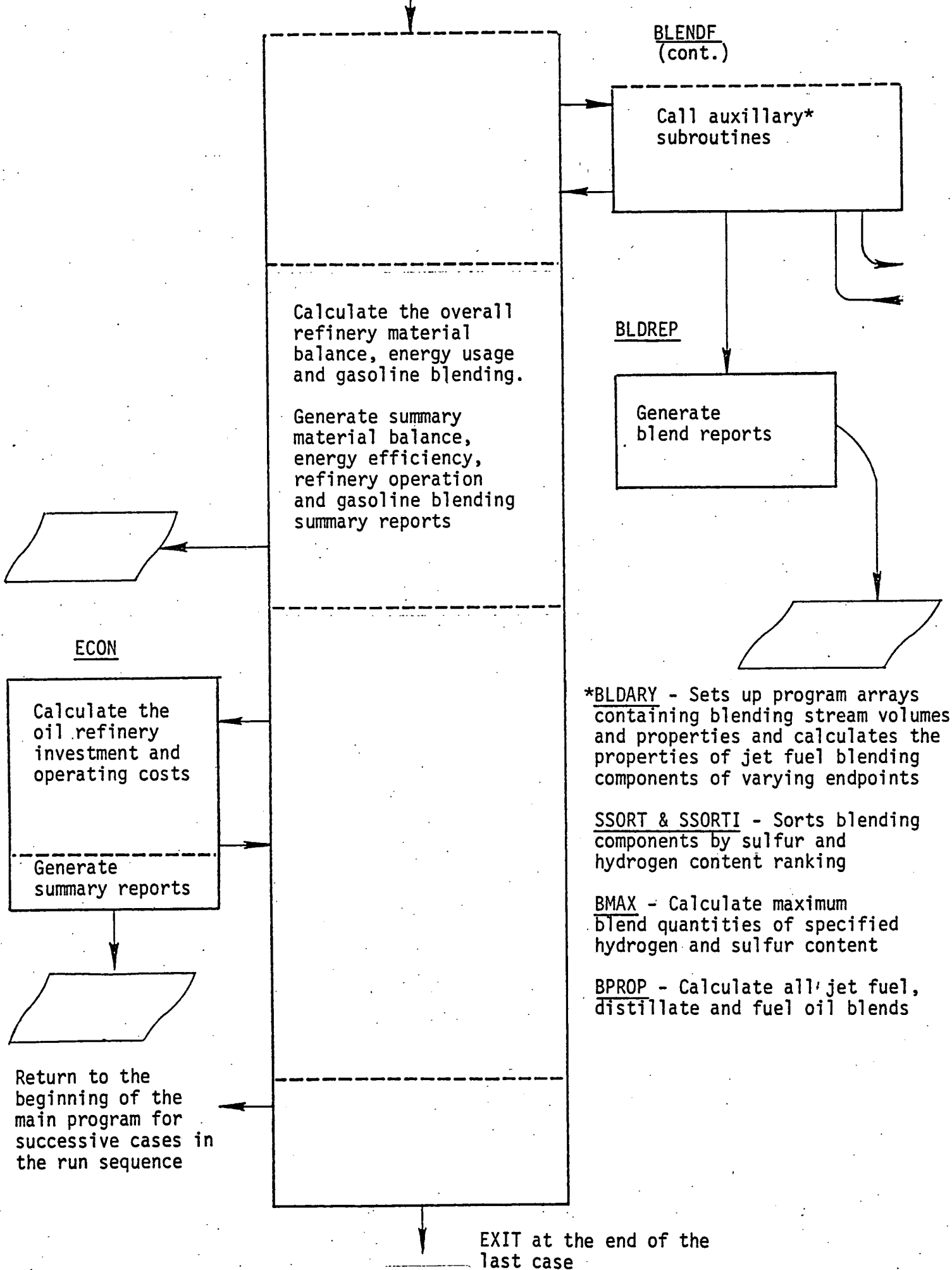
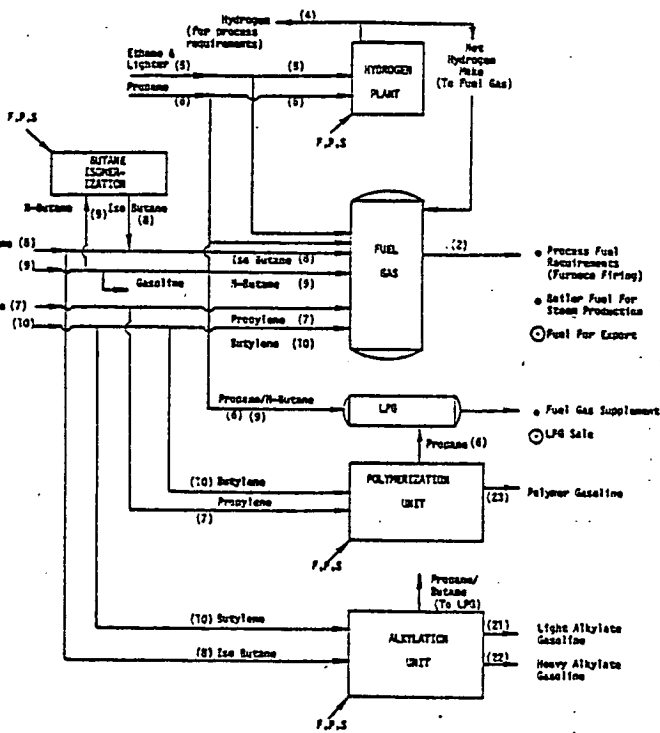


EXHIBIT 3

REFINERY SIMULATION BLOCK FLOW DIAGRAM

LIGHT PDS DISTRIBUTION



PRODUCT BLENDING

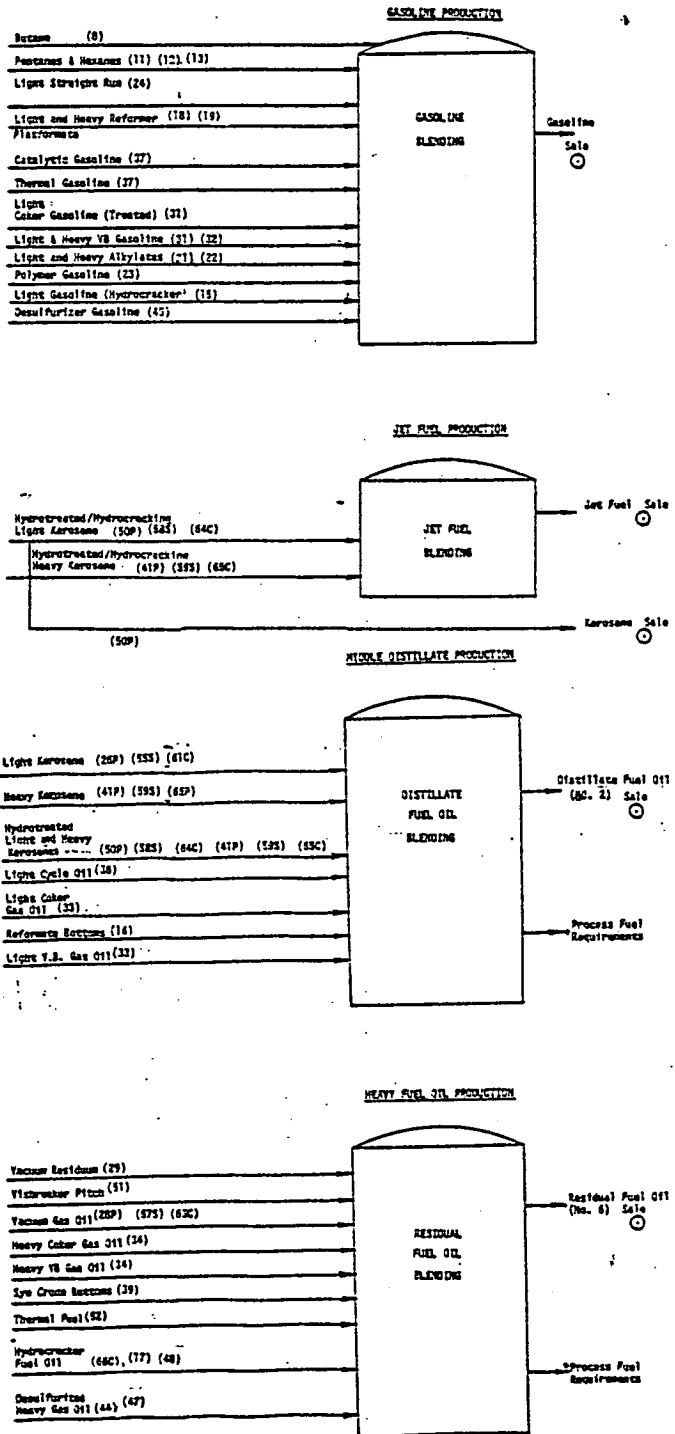


EXHIBIT 4

LIST OF DATA BASE CRUDE OILS

| PROGRAM INPUT IDENTIFICATION CODE | CRUDE OIL |
|---|--|
| 1 | Tigre-Venezuelan - 1.57%S, 24.7 API |
| 2 | Lot 17-Venezuelan - 0.98%S, 36.1 API |
| 3 | Bachequero-Venezuelan 2.4%S, 16.8 API |
| 4 | Nigerian Light - 0.14%S, 34.7 API |
| 5 | Amal-Libyan - 0.10%S, 35.8 API |
| 6 | Arzew-Algerian - 0.10%S, 44.1 API |
| 7 | Bakr-Egyptian - 4.4%S, 19.6 API |
| 8 | Light Arabian - 1.65%S, 34.2 API |
| 9 | Agha Jari-Iranian - 1.34%S, 34.3 API |
| 10 | Kuwait - 2.53%S, 31.4 API |
| 11 | Paraho Shale Oil - 0.71%S, 19.3 API |
| 12 | Tosco Shale Oil - 0.67%S, 21.0 API |
| 13 | Garrett Shale Oil 0.64%S, 25.0 API |
| 14 | Kentucky Coal Synthoil - 0.22%S, 5.9 API |
| 15 | Prudoe Bay Alaska - 1.04%S, 26.8 API |
| 16 | Ekofisk-North Sea- Norwegian - 0.18%S, 35.6 API |
| 17 | West Texas Sour - 1.9%S, 34.0 API |
| 18 | South Louisiana Ostrica - 0.31%S, 32.3 API |
| 19 | Louisiana Delta - 0.30%S, 30.6 API |
| 20 | East Texas 0.3%S, 38.0 API |
| 21 | Utah Aneth - 0.12%S, 40.9 API |
| 22 | Wyoming Sour - 2.4%S, 24.9 API |
| 23 | Oklahoma Golden Trend - 0.20%S, 39.9 API |
| 24* | California Elk Hills - 0.61%S, 26.6 API |
| 25 | California Wilnington - 1.43%S, 21.7 API |
| 26 | Canadian Pembina - 0.83%S, 32.7 API |
| 27-35 | Assay Data, as input for additional crude oils |

* Incomplete assay data - do not use without inputting assay data.

EXHIBIT 5

INTERNAL REFINERY STREAM AND PROCESS IDENTIFIERS

| <u>Program Identification Number</u> | <u>Description</u> |
|--|---|
| 1 | Refinery Steam Consumption |
| 2 | Refinery Fuel Consumption |
| 3 | Refinery Power Usage |
| 4 | Hydrogen (BFOE) |
| 5 | Ethane and lighter (BFOE) |
| 6 | Propane |
| 7 | Propylene |
| 8 | Isobutane |
| 9 | n-Butane |
| 10 | Butylene |
| 11 | Pentanes (from crude oil) |
| 12 | Reformer Feed Preparation Overhead (C5/C6) |
| 13 | Distillate Hydrocracker Pentanes (IC5/NC5) |
| 14 | Heavy Hydrocrackate (from both distillate and gas oil) |
| 15 | Light Hydrocrackate (from gas oil hydro- cracker) |
| 16 | Reformer Feed Preparation Bottoms |
| 17 | Distillate product from gas oil hydro- cracker |
| 18 | Light Reformate |
| 19 | Heavy Reformate |
| 20 | Total Reformate |
| 21 | Light Alkylate |
| 22 | Heavy Alkylate |
| 23 | Polymer Gasoline |
| 24 | Light Straight Run Gasoline |
| 25 | Heavy Straight Run Naphtha |
| 26 | Petroleum Light Kerosene |
| 27 | Petroleum Heavy Kerosene |
| 28 | Petroleum Vacuum Gas Oil |
| 29 | Vacuum Bottoms Reduced Crude |
| 30 | Reduced Crude |
| 31 | Light Coker/Visbreaker Gasoline |
| 32 | Heavy Coker/Visbreaker Gasoline |
| 33 | Light Coker/Visbreaker Gas Oil |
| 34 | Heavy Coker/Visbreaker Gas Oil |
| 35 | Total Coker/Visbreaker Gas Oil |
| 36 | Coke produced from Coker |
| 37 | Full range cracked gasoline (FCC/TCC) |

| | |
|----|---|
| 38 | Light cycle oil from gas oil cat cracker |
| 39 | Tower bottoms from gas oil cat cracker |
| 40 | Desulfurized light cycle oil |
| 41 | Hydrotreated straight run diesel |
| 42 | Desulfurized light coker gas oil |
| 43 | Distillate product from Gas Oil desulfurizer |
| 44 | Gas oil product from Gas Oil desulfurizer |
| 45 | Gasoline byproduct from all desulfurization |
| 46 | Stream 43, but with Coker/Visbreaker Feed Source |
| 47 | Stream 44, but with Coker/Visbreaker Feed Source |
| 48 | Stream 17, but with Coker/Visbreaker Feed Source |
| 49 | Composite Petroleum Crude Oil |
| 50 | Hydrotreated Petroleum Light Kerosene |
| 51 | Visbreaker Pitch |
| 52 | Thermal fuel produced from the Gas Oil Thermal cracker (all 400+ material) |
| 53 | Composite Shale Oil |
| 54 | Composite Coal Syn Crude Oil |
| 55 | Shale Oil Light Kerosene |
| 56 | Shale Oil Heavy Kerosene |
| 57 | Shale Oil Gas Oil |
| 58 | Hydrotreated Shale Oil Light Kerosene |
| 59 | Hydrotreated Shale Oil Heavy Kerosene |
| 60 | Hydrotreated Shale Oil Gas Oil |
| 61 | Coal Oil Light Kerosene |
| 62 | Coal Oil Heavy Kerosene |
| 63 | Coal Oil Gas Oil |
| 64 | Hydrotreated Coal Oil Light Kerosene |
| 65 | Hydrotreated Coal Oil Heavy Kerosene |
| 66 | Hydrotreated Coal Oil Gas Oil |

EXHIBIT 5 (cont'd)

INTERNAL PROCESS UNIT IDENTIFIERS

| <u>Identification Number</u> | <u>Description</u> |
|----------------------------------|-------------------------------------|
| 1 | Total crude unit capacity |
| 2 | Visbreaker |
| 3 | Catalytic Cracker (petroleum) |
| 4 | Thermal Cracker (petroleum) |
| 5 | Alkylation Unit |
| 6 | Polymerization Unit |
| 7 | Distillate Desulfurizer (petroleum) |
| 8 | Gas Oil Desulfurizer (petroleum) |
| 9 | Distillate Hydrocracker (petroleum) |
| 10 | Gas Oil Hydrocracker (petroleum) |
| 11 | Catalytic Reformer |
| 12 | Hydrogen Plant |
| 13 | Butane Isomerization Unit |
| 14 | Fluid Coker |
| 15 | Kerosene hydrotreater (petroleum) |
| 16 | Crude Unit (petroleum feed) |
| 17 | Crude Unit (shale oil feed) |
| 18 | Crude Unit (coal oil feed) |
| 19 | Shale Oil Hydrocracker (gas oil) |
| 20 | Coal Oil Hydrocracker (gas oil) |
| 21 | Shale Oil Hydrotreater (kerosene) |
| 22 | Coal Oil Hydrotreater (kerosene) |

EXHIBIT 6

Linear Viscosity Blending Chart

NOTE: Use this chart at 210°F for use with the Gordian Fuels Blending Model. Conversions may be made from either Saybolt Seconds Universal (SSU) or Saybolt Seconds Furol (SSF) viscosities.

LINEAR BLENDING SCALE

SAYBOLT UNIVERSAL SECONDS

EXHIBIT 6 (cont'd)

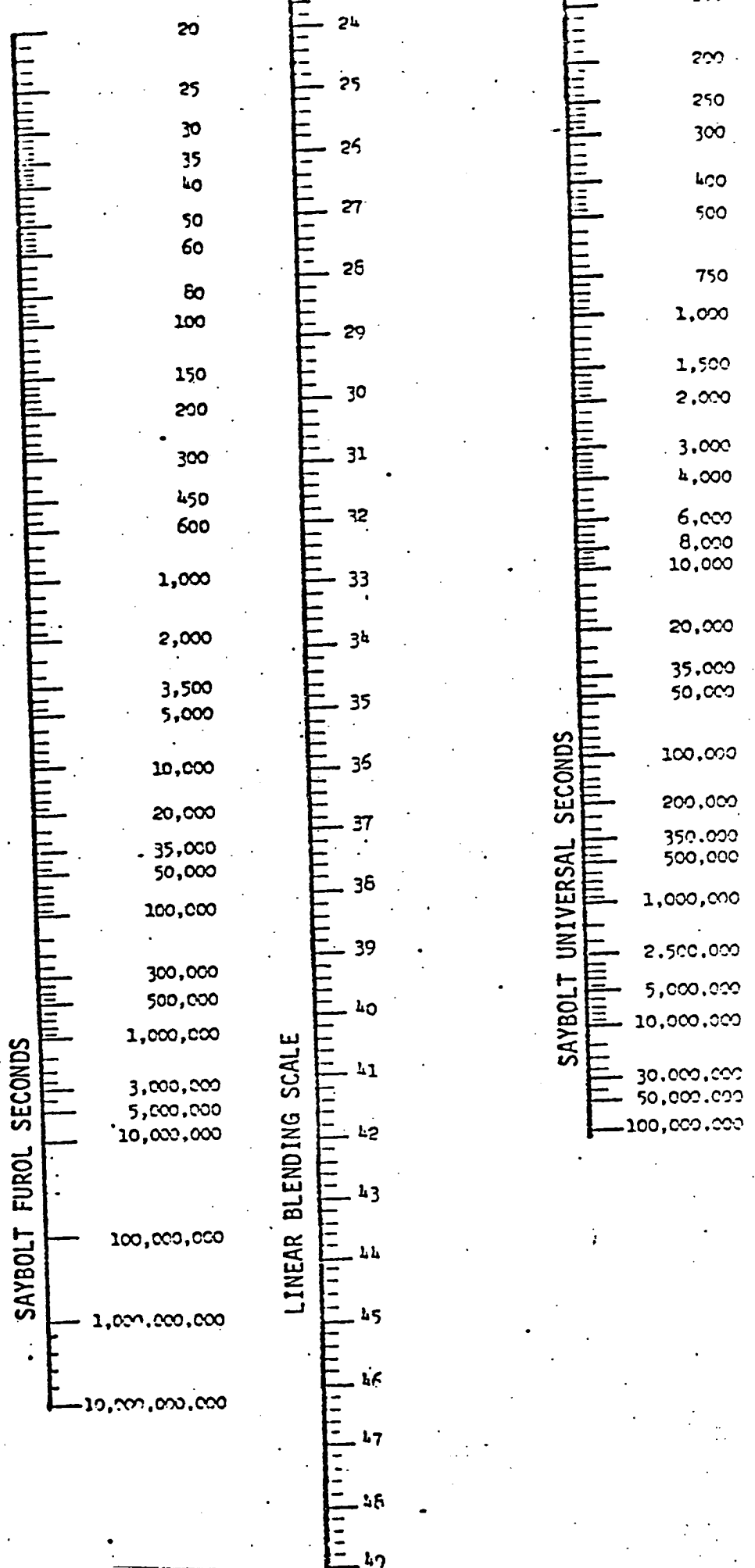


EXHIBIT 7
ECONOMIC DATA BASE

1. CAPITAL INVESTMENT COSTS

The unit capital investment costs (Jan.1, 1977 basis) stored in the economic subroutine are shown below:

| <u>Refinery Unit</u> | <u>Unit Capital Investment Cost</u> (\$/bpsd) | <u>Reference Unit Size</u> (bpsd) | <u>Source</u> |
|----------------------------|--|--------------------------------------|---------------------------|
| Atmospheric Distillation | 190 | 20,000 | OGJ, Feb. 25, 1974, p.71 |
| Vacuum Distillation | 198 | 20,000 | OGJ, Mar. 4, 1974, p.100 |
| Catalytic Gas Oil Cracker | 699 | 40,000 | OGJ, Apr. 15, 1974, p.66 |
| Thermal Gas Oil Cracker | 185 | 20,000 | OGJ, Apr. 8, 1974, p. 74 |
| Kerosene Hydrotreater | 122 | 30,000 | HP, September, 1976 |
| Gas Oil Desulfurizer | 614 | 50,000 | OGJ, Mar.1, 1976 p. 120 |
| Distillate Desulfurizer | 267 | 30,000 | HP, September, 1976 |
| Fluid Coking | 770 | 20,000 | OGJ, May 24, 1976 |
| Vacuum Bottoms Visbreaker | 185 | 20,000 | OGJ, Apr. 8, 1974 |
| Distillate Hydrocracker | 747 | 15,000 | HP, September, 1974 |
| Gas Oil Hydrocracker | 904 | 20,000 | OGJ, Mar. 25, 1974 p. 120 |
| Catalytic Naphtha Reformer | 543 | 20,000 | OGJ, Apr. 22, 1974 p. 130 |
| Alkylation | 1193 | 10,000 | OGJ, Apr. 8, 1974 p. 74 |
| Polymerization | 800 | 500 | "Gordian Estimate" |
| Isomerization | 222 | 6,650 | HP, September, 1974 |
| Hydrogen Manufacture | 170/mscfd | 50 mmscfd | OGJ, Mar. 25, 1974 p. 120 |

2. ECONOMICS OF SCALE

The following power law formula is used in the model to calculate economics of scale.

$$\left(\frac{I_1}{I_2} \right) = \left(\frac{C_1}{C_2} \right)^N$$

Where I_1, I_2 are investment costs C_1, C_2 are the corresponding capacities in BPD and N is the power law exponent.

Standard sizes and costs used are given in part (1) above, the power law exponents contained in the model appear on the next page.

| <u>Refinery Unit</u> | <u>Capacity Ratio Exponent</u> | | | <u>Average</u> |
|----------------------------|--|--|-----------------------------------|----------------|
| | <u>Hydrocarbon Processing</u> (May, 1975 p.111) | <u>Chemical Engineering</u> (June 15, 1970) | <u>OGJ</u> (see section 5.1.1) | |
| Atmospheric Distillation | 0.70-0.85 | 0.90 | 0.77 | 0.805 |
| Vacuum Distillation | 0.70 | 0.70 | 0.75 | 0.717 |
| Catalytic Gas Oil Cracker | 0.70 | 0.55 | 0.86 | 0.703 |
| Thermal Gas Oil Cracker | | 0.70 | | 0.700 |
| Kerosene Hydrotreater | | 0.65 | | 0.650 |
| Gas Oil Desulfurizer | 0.80 | | | 0.800 |
| Distillate Desulfurizer | 0.65-0.85 | | | 0.750 |
| Fluid Coking | | | 0.72 | 0.720 |
| Vacuum Bottoms Visbreaker | | 0.65 | 0.620 | 0.635 |
| Distillate Hydrocracker | 0.75 | | | 0.750 |
| Gas Oil Hydrocracker | | | 0.75 | 0.750 |
| Catalytic Naphtha Reformer | 0.70-0.85 | 0.61 | 0.80 | 0.740 |
| Alkylation | | 0.60 | 0.60 | 0.600 |
| Polymerization | | | 0.58 | 0.580 |
| Isomerization | | | 0.65 | 0.650 |
| Hydrogen Manufacture | 0.65-0.70 | | 0.70 | 0.680 |

* The same exponents are assumed for processing shale and coal oil kerosene and gas oil cuts.

3. VARIABLE OPERATING COSTS

The catalyst and chemicals cost figures are in terms of costs per barrel of crude throughput. In order to update the chemicals and catalysts costs, the Nelson-Chemicals Index (Oil and Gas Journal) was used. All chemicals and catalyst costs used in the model are on a Jan. 1, 1977 basis. Water cost were based on an average reported consumption (gal/barrel), at a unit cost assumed to be \$0.05/1000 gals.

The total variable operating costs used in the model (chemicals, catalyst, and water) are shown below:

| <u>Unit</u> | <u>Variable Cost (\$/Bbl)</u> |
|----------------------------|-------------------------------|
| Atmospheric Distillation | 0.015 |
| Vacuum Distillation | 0.019 |
| Catalytic Gas Oil Cracker | 0.074 |
| Thermal Gas Oil Cracker | 0.071 |
| Kerosene Hydrotreater | 0.086 |
| Gas Oil Desulfurizer | 0.115 |
| Distillate Desulfurizer | 0.115 |
| Fluid Coking | 0.024 |
| Vacuum Bottoms Visbreaker | 0.022 |
| Distillate Hydrocracker | 0.423 |
| Gas Oil Hydrocracker | 0.423 |
| Catalytic Naphtha Reformer | 0.183 |
| Alkylation | 0.990 |
| Polymerization | 0.274 |
| Isomerization | 0.043 |
| Hydrogen Manufacture | 0.097 (\$/mscf) |

The fuel power and steam consumptions are calculated for each unit based on the data base values contained in subroutine UBASE. Fuel and steam is produced from crude oil and intermediate streams and value is a function of crude oil prices. Electric power usage for the total refinery is calculated by the model and reported in thousands of kilowatt hours per day. The cost of electricity is input in cost per kilowatt hours by the user.

4. FIXED OPERATING COSTS

The fixed operating costs include the labor and maintenance costs. Labor costs are assumed to be independent of throughput, units are assumed to be operated on a 24 hour per day basis. Labor use (men per shift) figures were obtained from A Guide to Refinery Operating Costs, by W.L. Nelson, Petroleum Publishing Company, 1976. Labor rates used were: operators \$10.00/hr, supervisors - \$12.50/hr. In each case the labor rates are inclusive of benefits.

Maintenance costs are given as a per cent of the corrected onsite unit capital investment cost. The computer model utilizes these maintenance figures to calculate the maintenance cost in dollars per day. The maintenance and labor cost numbers used by the computer are listed below:

| <u>Unit</u> | <u>Labor Cost</u> (\$/day) | <u>Maintenance</u> (% Capital Investment Per Annum) |
|----------------------------|-------------------------------|---|
| Atmospheric Distillation | 806.10 | 4.0 |
| Vacuum Distillation | 1002.00 | 3.5 |
| Catalytic Gas Oil Cracker | 1545.00 | 4.0 |
| Thermal Gas Oil Cracker | 1245.00 | 5.5 |
| Kerosene Hydrotreater | 720.00 | 4.0 |
| Gas Oil Desulfurizer | 720.00 | 4.0 |
| Distillate Desulfurizer | 720.00 | 4.0 |
| Fluid Coking | 1485.00 | 5.5 |
| Vacuum Bottoms Visbreaker | 1059.00 | 4.3 |
| Distillate Hydrocracker | 1065.00 | 4.0 |
| Gas Oil Hydrocracker | 1065.00 | 4.0 |
| Catalytic Naphtha Reformer | 1012.50 | 4.0 |
| Alkylation | 1050.00 | 5.5 |
| Polymerization | 505.00 | 4.3 |
| Isomerization | 1440.00 | 3.5 |
| Hydrogen Manufacture | 585.00 | 3.5 |

REFINERY OFFSITES

Other refinery investment costs include supporting utilities, tankage, off limits battery piping, roads and accessways, sewers and drains and dock facilities. These are calculated as a function of Nelson refinery using the attached correlation presented by Nelson.

The basic refinery process unit investment is multiplied by the percentage given to obtain the offsites portion of the total investment.

OFF SITES INVESTMENT - AS A % OF ON SITES

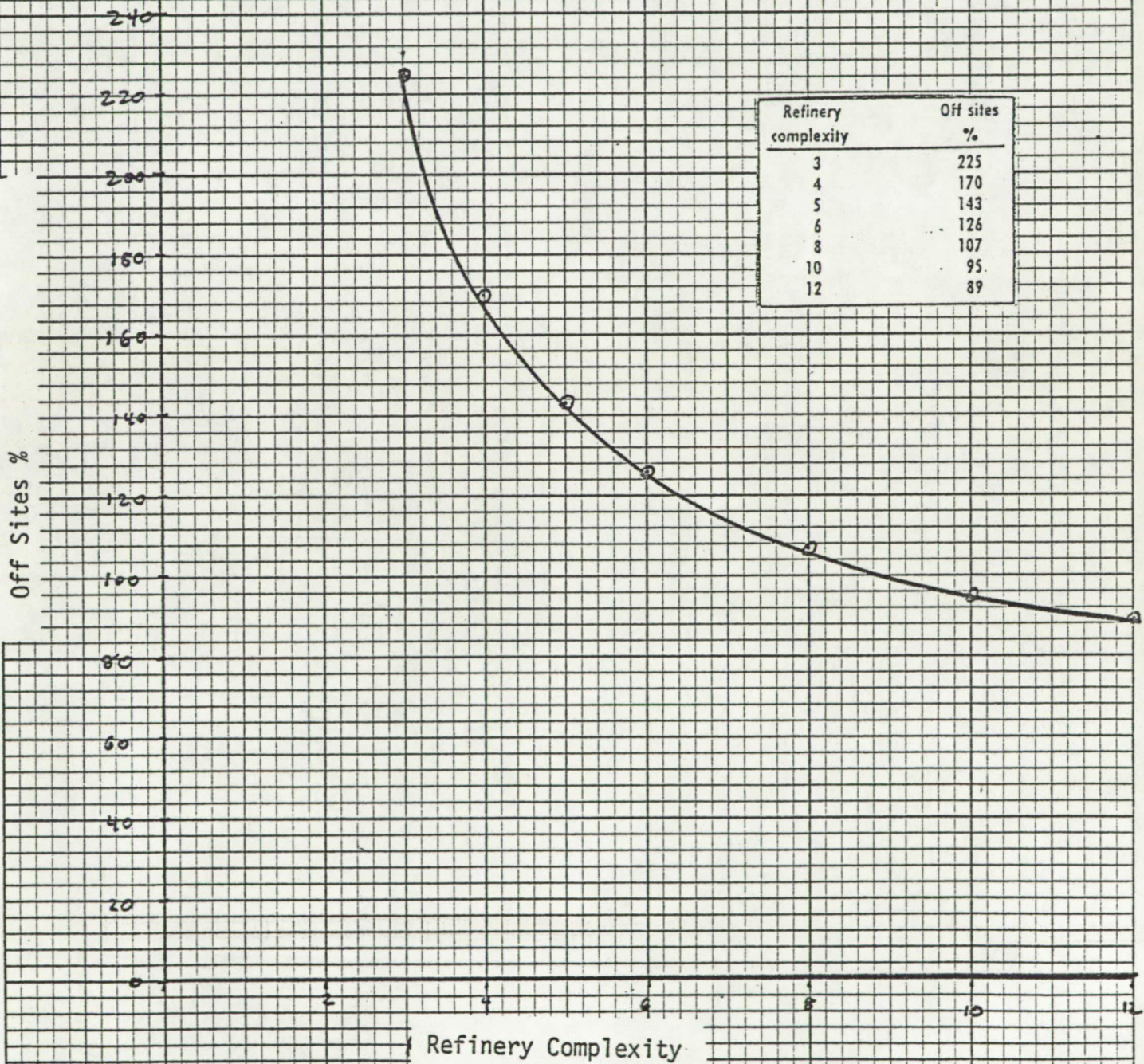


EXHIBIT 8

INPUT PRINTOUT FOR SAMPLE BASE CASE AND DEPENDENT CASES

The following page reproduces the computer printout for input representing the feature of base case use with subsequent dependent cases for parametric studies. The first group of images represent the case shown as Exhibit 1; the input ICASE = 1 indicates that this is a base case. The second group represents a subsequent calculation, in which the only change is a requirement of jet fuel production at 575°F end point and 13.0% hydrogen (compared to 600°F and 12.8% in the base case.) The input ICASE=2 indicates that this case is dependent on the preceding ICASE=1 calculation and only the indicated inputs change. The third group represents a second dependent calculation in which 500 BPD each of 0.05 and .10% sulfur middle distillate and 0.3 and .35% sulfur residual fuel oils are to be produced, and maximum volumes of 0.15% sulfur distillate and 0.6% sulfur residual are to be calculated and reported. The input ICASE=3 indicates that this is a dependent study of the preceding ICASE=1, but it terminates the series of dependent cases.

FUELS BLENDING MODEL-GORDIAN ASSOCIATES

1...INPUT CARD IMAGES

```

$FOATA
IREP=1, ICASE=1,
SVSKHT=1, SVCKHT=1, SVSGHT=1, SVCGHT=1,
CV(9)=3300.0, CV(11)=3200.0, CV(14)=3300.0, ALKY=200.0, EI=100.0, FCC=50000.0,
CCNV=70.0, VACC=1000.0, GOMYC=500.0, MOCE=2, HTKERC=1000.0, MYC= 50.0, POLY=500.0,
REF=2000.0, SEFPCN=95.0, TCC=1000.0, COKER=5000.0, VACS=20000.0, VACC=20000.0,
SOKMT=5000.0, CCKHT=5000.0, CGCHYC=15000.0, SGCHYC=100.0, DIESEL=500.0, KERO=500.0,
DPBBL=70*10.00, IVESTCC=3.15, CENTXN=2.5, STRF=0.92, PFPR=9.00,
PCBBL=9.00, 10.50, 15.00, 14.75, 13.75, 13.50, 16.80, 16.00, 14.70, 12.30, 8.00, 9*0.0,
CODES=1000.0, MOCE=1000.0, MOHYC=1000.0, EPSPEC=600.0, HDOSPEC=12.8,
SPECMD=0.2,
$END

```

FUELS BLENDING MODEL-GORDIAN ASSOCIATES

1...INPUT CARD IMAGES

```

$FOATA
ICASE=2,
EPSPEC=575.0, HDOSPEC=13.0,
$END

```

FUELS BLENDING MODEL-GORDIAN ASSOCIATES

1...INPUT CARD IMAGES

```

$FOATA
ICASE=1,
SPH1=.05, SPH2=0.10, SPECMD=0.15, SPR1=0.3, SPR2=.35, SPECRF=0.6,
VP1=500.0, VP2=500.0, VR1=500.0, VR2=500.0,
$END

```